ORTHOPÆDICS IN MEDICAL PRACTICE

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Translator's Preface.

This book is a translation of "Die Orthopädie in der inneren Medizin," and is not intended as a text-book on orthopædic surgery, which, as a rule, is largely devoted to matters that have little direct interest for the physician. But a glance at its contents, however, is sufficient to show how few are the diverse branches of medicine on which orthopædics has not at least some bearing.

As may be gathered from the introduction written by Professor Lorenz, its object is to provide the medical practitioner with fuller information as to the present-day developments in this special field, so that he may make personal use of this knowledge in his practice or, realizing what specialistic treatment is capable of attaining, he may be guided to avail himself of the services of the orthopædic surgeon. At the same time, the subject of diagnosis in orthopædic conditions as they present themselves to the physician is dealt with fully.

In regard to the methods of treatment, the authors have aimed at presenting a comprehensive review of current opinions from all sources. In addition to laying this before English-speaking readers, the translation may be also of use in making more widely known those special methods associated with the name of Professor Lorenz, which are finding an ever-increasing

employment by those who have become familiar with them.

A number of annotations have been added to the original text for the purpose of explanation or amplification, where such seemed desirable, or of recording recent literature, and an Index has also been appended.

For the grateful privilege of being entrusted with the translation of this work I gladly take the opportunity of expressing my thanks to my former chief and teacher, Professor Lorenz, and to his assistant, Dr. Saxl.

L. C. Peel Ritchie.

7, Alva Street, Edinburgh,
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Preface.

THERE exists a more intimate connection between internal medicine and orthopædic surgery than at the first glance might appear to be the case. Closer scrutiny will make it clear, however, that it is under the eyes of the physician that the early symptoms, at first subtle and therefore easily overlooked, of not only many congenital but also of nearly all acquired deformities reveal themselves.

To detect threatening mischief in good time and to submit it as soon as possible to an appropriate specialistic treatment will always be a most important part of the mission fulfilled by the general practitioner, whose work chiefly lies within the sphere of internal medicine. Accordingly even the most superficial familiarity with the clinical pictures of orthopædic conditions coming under his observation will be valuable and bring home to him the significance which orthopædy has in medical practice.

With but a slight acquaintance with orthopædics the pure physician and the family doctor especially will be able to escape the odium attached to a mistaken diagnosis and a consequent useless course of treatment. One may cite a few cases in point.

The altered general appearance which he will observe in a child that but shortly before was lively and bright, and the way in which it holds itself bent,

often to one side, thus suggesting skoliosis, will rouse his suspicions at once of an early spinal caries, and will save him from the error of prescribing opiates for the pain in the stomach, often complained of by a child in such case, and of treating its slouching attitude with gymnastics and massage.

By convincing himself, as he may do without difficulty, that a part of the spinal column is held rigidly by reflex muscular contraction, any medical man who has preserved even but a faint recollection of such clinical pictures will be quick to surmise that he is dealing with a condition of spondylitis, even in the event of the patient being an adult and the spine showing not a trace of a hump. Quite a slight knowledge of orthopædics in connection with internal medicine will prevent the mistake, only too frequently made, of including the spondylitis of adults under the comprehensive diagnosis of rheumatism and of letting the patient be treated in thermal baths by massage and such like, owing to lack of recognition of the fact that a hump makes its appearance in adults only at a late stage of the disease, and perhaps not at all.

In contrast with this, the physician who has studied orthopædics to some slight extent will not mistake for an angular curvature due to caries a relatively innocuous kypho-skoliosis of the lumbar region, though accompanied by slight indications of nerve irritation; nor will he make the diagnosis of a cold abscess on the strength of the false fluctuation presented by the muscles of the back covering the prominence of the deformity. Again, he will not rack his brains for an explanation of paralytic manifestations in the legs, when a cursory examination of the abdomen is suffi-

cient to prove the existence of a psoas abscess, which can be ascribed to a lumbar spinal caries, in spite of the absence of humpback.

These instances are not merely fanciful, but represent actual occurrences. Errors of this or a like nature may trip up diagnosticians at the height of their profession and may repeat themselves in the course of a lengthy practice.

It is a not infrequently recurring experience to find that early disease of the hip-joint, with prominent and typical symptoms, at any rate in adults or adolescents, is taken for sciatica and treated accordingly. Similarly in early tuberculous disease of the joints of the knee, ankle, or foot, an adult patient may be subjected to various useless or even harmful procedures before the true nature of his trouble is recognized. Then, on the other hand, while the trained eye of the neurologist may at once detect the initial symptoms of sclerosis of the dorsal columns of the cord that had been wholly hidden from the non-specialist, yet the former diagnostician, who can investigate with admirable delicacy the state of the reflexes, may possibly quite overlook the comparatively coarse signs of a commencing tabetic arthropathy, or, otherwise, estimate too lightly its importance, so that no check is offered in time to the ensuing flail-joint.

As a general rule, the possibility of securing immediate and considerable relief for such patients by mechanical devices has too little attention given to it as against treatment by internal remedies.

As an instance of this, mention may be made of a patient who suffered from marked tabes. He was for a long time under the observation and treatment of his

physician, a man of unquestionably high scientific attainments, but so far attempts to bring him relief had not met with the least success. One day this patient sought from his doctor an explanation as to why it was that he felt so remarkably more comfortable when he stuck both his hands in the pockets of his trousers. "Pure imagination," was the reply given, without, however, carrying conviction to the patient. When, however, he came out afresh with the inquiry as to how it was that he felt still better when he kept his hands in the pockets of his riding-breeches when wearing these in place of his lounge-suit trousers, his doctor then declared that there was not the least doubt by now that it was a matter of auto-suggestion. And yet the invalid was right, while the profoundest knowledge of the anatomy of the cerebrospinal nervous system was unable to throw light on the question. Although the patient felt so comfortable with his hands buried in the pockets of the riding-breeches of his choice, still it was even more necessary for him to use at any rate one of them for holding his stick. He helped himself out of this dilemma, independently of the aid of science, by wrapping a linen bandage round his abdomen. Still this was not so satisfying as having his hands in his riding-breeches. At a much later date a vertebral arthropathy was demonstrated in this patient in a skiagram that was taken. Only then, when much too late, there was ordered a corset, the effect of which the patient could hardly sufficiently praise. The preference which he felt for his riding-breeches was then, of course, plain, for such breeches, unlike ordinary trousers, have cross-pockets with the openings at the top, and when the patient thrust his open hands flat into them from

above, he thus improvised a corset of a kind, while the lower ends of his forearms enabled him to support his anterior abdominal wall still more effectively than he was able to do when wearing his ordinary trousers in which the pockets opened sideways.

In consideration of the fact that tabetic patients feel more comfortable when wearing a supporting corset, even though not suffering from an arthropathy of the spinal column, one has reason for granting to the mechanical or orthopædic indications a wider scope in the treatment.

Similarly many a hemiplegic patient would not have for so long to complain of his helplessness, were the physician to counteract the development of a contracture of the foot from the very beginning. Many a case with the favourite diagnosis of gout in the foot and of supposed sciatica and meralgia would be cured speedily and soundly, and without the necessity of dietetic penances, if the view were generally accepted that not only the aggravated flat foot recognizable even from the boots, but also the yielding, flexible foot, which is incompetent to support the weight of the body without spreading itself out to some extent, is a source of pain and at the same time a grateful object for orthopædic treatment, to which it should be submitted without delay.

The wonderful effect in subduing pain that orthopædic treatment by joint fixation produces in acute rheumatism certainly need not fear comparison with the results of treatment by drugs.

Immediate absolute fixation of the joints in gonorrhœal arthritis is incomparably superior to the injection of morphia which is often the choice at first, and

experience shows that the early fixation in no way favours the joint ankylosis which is dreaded, but is indeed much more calculated to prevent that occurrence in virtue of its quietening the acute inflammatory process.

In the management of arthritis deformans, too, the interests of the patient are better consulted when the value of orthopædic methods of treatment is more fully appreciated, than if drugs and balneotherapy are the sole remedial measures adopted. Again there is no doubt of the great benefit secured in infantile paralysis by early orthopædic treatment in the acute stage, so that over-stretching of the affected muscles may be prevented in good time.

Many other examples might be thus given to show that orthopædy is fitted to play a not unimportant *rôle* in internal medicine, so soon as one has learned how to estimate correctly the value of its services.

Once connecting side-tracks have been laid down between different specialized paths of study, there is but little doubt that the increasing use made of them will lead to a still closer linking up. As the association between neurology and orthopædy, due to the united exertions of specialists in these lines, has already grown to such an extent that at least the treatment of the after-effects of previous lesions has become almost exclusively the domain of the orthopædist, then it may not prove too difficult a matter for his expansive speciality gradually to take firmer root in internal medicine generally. This is already the case to the fullest extent in the treatment of rickets, in which it falls to us to prevent deformities or to correct those already developed.

Further reference may be made to the affections which

arise in consequence of acute infective diseases, and typhoid spondylitis may be quoted as an example, the early recognition and treatment of which will save the patient much distress.

The shrinking and contraction in the thorax to which pleuritic exudations may lead up, with resultant deformity of the chest and curvatures of the spinal column, likewise demand a careful orthopædic after-treatment.

Attempts at the treatment of pulmonary tuberculosis by mechanical measures have not been left still untried, and I would refer in this connection to the most recent proposals (of Pedrazzini and de Vecchi) to force the musculature of the upper thoracic aperture to increased activity by mechanical procedures, in which, however, the patient is subjected to the discomfort of lying on his back with the head lowered, and is deprived of the use of his arms.

If it is true that the apices of the lungs are the seat of election for the growth of tubercle on account of their deficient aeration, and if the bowed attitude of the individual predisposed to phthisis is a probable, and perhaps the most important, cause of this insufficient aeration, then the natural indication would seem to be to train such patients by orthopædic means, but without putting them about or limiting their freedom of movement, to hold themselves up so as to straighten the forward slope of the upper dorsal segment and thus assist the aeration of the apices of the lungs. Such an improved posture can be enforced by establishing an elongated lordotic curve in the sacro-lumbo-dorsal segments, extending into the lower dorsal segment of the spinal column.

A corresponding endeavour is indicated for the

creation in a similar fashion of more favourable conditions for the action of the heart, when it is hypertrophied and cramped by its surroundings.

The condition of orthotic or lordotic albuminuria is a familiar instance of the marked extent to which the function of the internal organs may be dependent in some circumstances on the posture of the spinal column, and yet the causal nexus between body posture and organic function is in this case by no means so intimate as in the foregoing conjectures.

The condition of general asthenia (Stiller) also, with its diversified manifestations in the external and internal organs (splanchnoptosis, rhachialgia, &c.), offers a field for mutual work in orthopædy and internal medicine.

It is these associations already actually existing between the specialities, and waiting to be more closely worked up in the near future, that have given rise to the desire expressed by my esteemed friend Professor Lothar von Frankl-Hochwart to conjoin a text-book on "Orthopædics in Medical Practice" with the monumental work of Nothnagel as an appendix to it.

My assistant, Dr. Alfred Saxl, has undertaken the fulfilment of this wish under my editorial collaboration. Whatever may be the opinion formed of the result, it will not have been without use, if the physician is willing to be reminded thereby that orthopædists not only offer their ready and zealous aid in the service of internal medicine but also have means of treatment at their command that are capable of materially assisting internal medication.

ADOLF LORENZ.

Vienna, March, 1911.

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CHAPTER I.

Diseases of the Respiratory System.

WITH well-marked curvatures of the spinal column alterations of the most serious kind may result in the **lungs,** which are mechanically hindered by the consequent changes in their form and position, while serious lesions of the lung tissue may result or be induced. These alterations in form and position of the lungs, in common with usually all the thoracic organs, are the natural consequences of the often excessive distortions of the trunk. The trunk undergoes in severe *skoliosis* not only a considerable shortening in the vertical direction and a complete deformation in the other directions, but is also altered as a whole in that it is displaced laterally while its whole structure is twisted. The lungs, being plastic, must accordingly adapt themselves, both in position and shape, to the thoracic walls enclosing them, and so may assume most curious conformations.

As a simple case we may take one of a marked dorsal skoliosis with the *convexity to the right-hand side,* and consider the form of one of its costal arches (fig. 1). We find then the oblique diameter of the

thorax from the left posteriorly to the right anteriorly to be notably contracted, while the other oblique diameter, corresponding to the bulge of the ribs on the right side behind, and on the left side in front, is lengthened. The curve of the ribs then in such a case transforms the right pleural cavity into a narrow space reduced especially posteriorly. In skoliosis still more developed, the rib may virtually be wrapped round the vertebra, so that no space remains between the rotated vertebral body and the posterior portion

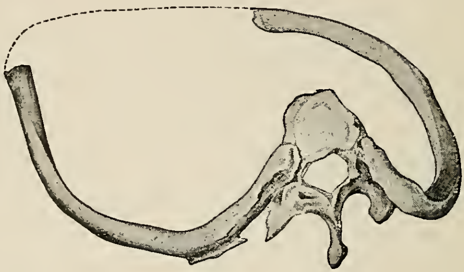

FIG. 1.

of the rib (fig. 2). The form of the posterior portion of that half of the thoracic cavity on the side of the convexity approximates then once more to the normal, and there does not then occur that compression of the lung, which in moderately severe cases gives rise to a flattened ribbon-like lobe of airless lung tissue. One finds not at all infrequently on the side of the *concavity* also a similar flattening out posteriorly of the corresponding lung, between the vertebral column and the chest wall. This is found at the extremities of the kypho-skoliotic curvature (Bachmann).

The altered position of the mediastinal cavity has also, of course, an influence on the deformation of

the lungs; the **mediastinum,** taking again, for instance, a dorsal skoliosis with the convexity to the right, is

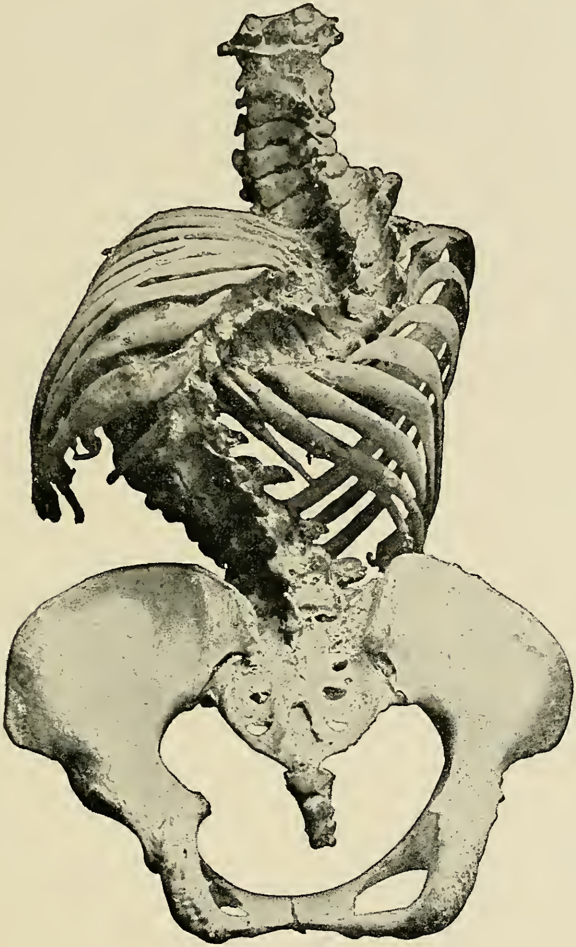

FIG. 2.

displaced, as is the vertebral column, to the right side posteriorly, and extends toward the middle line and forward to the sternum, which, except in the severest

forms of skoliosis, does not differ materially from the normal in its position and direction (Schulthess). The course of the **trachea,** which is attached rather firmly to the spinal column, undergoes no notable alteration.

The changes in shape and position of the lungs have been studied more particularly by Rokitansky, Bouvier, and Bachmann, who have found that, as a rule, the lung on the side of the concavity in the spinal curvature is the larger and the less affected, while that on the side of the convexity is the smaller and more deformed; this is generally true of dorsal curvatures of moderate severity, but not of sharp curvatures presenting a short diameter. The complex structure of the skoliotic thorax and the changes, secondarily resulting, in the lungs, influence naturally the position of their extremities, which lie, it may be higher or lower, sometimes normally. In Bachmann's cases the borders of the lung were sometimes normally placed, sometimes an intercostal space lower; in those of Wullstein-Reineboth they were displaced upward for from one to one and a half intercostal spaces.

The base of the pleural cavity, the **diaphragm,** is similarly subjected to alterations corresponding to the deformity of the spine, but these changes are principally in its relation to the pelvis, not to the spine. The belief, frequently held formerly, that the diaphragm is always raised, has been shown by more exact observations (Bachmann) to be unfounded, for a depression of the diaphragm is most commonly present. This is readily understood since, as the curvature increases, the attachments of the diaphragm must also pass downward; further, the emphysema frequently ensuing in the lungs and a hypertrophy

of the heart may also contribute to this. A similar condition is also found in cases of purely kyphotic curvature of the spinal column. For instance, in a marked dorsal skoliosis with right-sided convexity, as the spine sinks to the right, the diaphragm will also be set obliquely, with the left half placed higher than the right, while the muscular portions pass down, not vertically, but obliquely to the left (fig. 8). When the halves of the diaphragm are set asymmetrically, the left one is more frequently the higher. "An elevated position of the diaphragm seems to occur most readily when there is a well-marked kyphotic curvature in the upper dorsal region. In such a case the dome of the diaphragm may reach up to the level of the third rib" (Schulthess). An elevation of the diaphragm is also found sometimes with an *angular curvature* in the lumbar region due to *spondylitis*. This is consequent on the great diminution of the vertical diameter of the abdominal cavity crowding the viscera up against the diaphragm. In an interesting preparation described by Nicoladoni, the limb of the diaphragm on the convex side of the curvature was nearly three times as broad as the other. There was no indication of any torsion having occurred. The aortic opening was long and spacious, as were also the lateral fissures for the azygos and azygos minor veins.

The lesions, which deformities of the thorax may cause in the lungs, are determined not only by the severity of the deformity but also by considerations in respect of the portions of lung affected. Slight degrees of skoliosis do not commonly cause any notable damage; but even the more trivial alterations

may be prejudicial if they involve the *apex of the lung,* specially liable as it is to tuberculosis. Any condition in the osseous chest wall, which may further restrict the comparatively limited respiratory excur-

FIG. 3.

sions of the apices, must have very great bearing on the development of tuberculosis at that site.

Lorenz (Oppelsdorf) found sixty-eight out of 174 phthisical cases (39 per cent.) to have some rigidity of the spinal column. With any rigidity of the vertebral column, owing to the fixation of the thorax the type of

respiration is essentially different from the normal; the circumference and the vertical and transverse diameters of the chest present only minimal variations between inspiration and expiration (Müller).

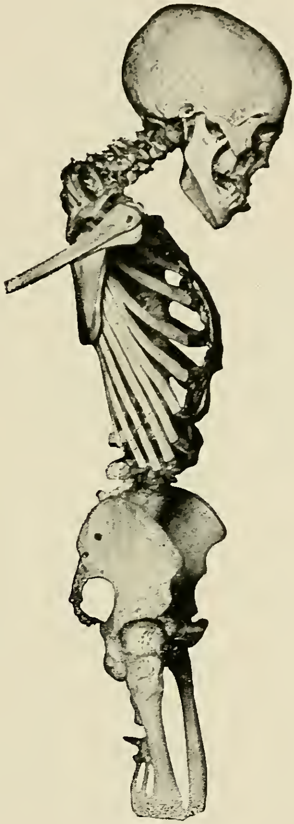

FIG. 4.

Aeration of the lungs is also poor in the case of a badly deformed skoliotic thorax; the respiratory movements are diminished, especially on the convex side, so that the inspiratory attitude is almost constantly main-

tained. In *tuberculous spondylitis* the respiratory activity may be similarly enfeebled. If there is a moderate gibbosity in the middle dorsal region (fig. 3), the lower ribs are then raised and lie almost horizontally, so that the thorax assumes the inspiratory

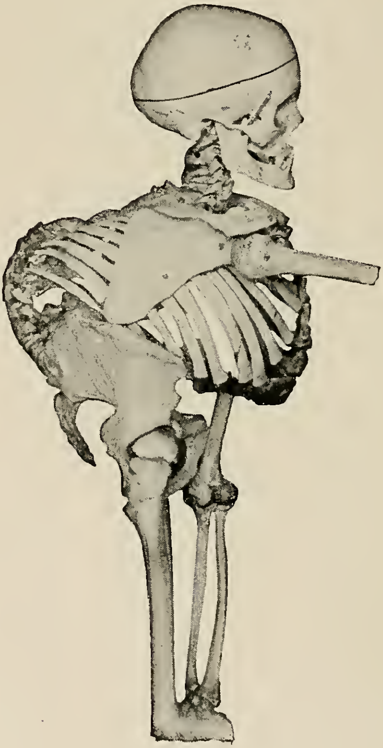

FIG. 5.

position; the chest breathing is accordingly greatly limited, and the patient depends chiefly upon his diaphragm. If the hump is situated in the upper dorsal region (fig. 4), then the ribs are inclined downward, often almost vertically so; in this type of flat elongated

thorax the diaphragmatic breathing in turn is hindered. This is also the case when there is a hump in the lumbar region (fig. 5), and the thorax is depressed forward, so much so that the diaphragm approaches the pelvic inlet. On the other hand, we often find a purely abdominal type of breathing in the cases of chronic affections of the spine with ankylosis, if there has developed paresis and atrophy of the respiratory muscles or ankylosis of the costo-vertebral articulations [1].

In regard to the connection noted between pulmonary tuberculosis and rigidity of the spinal column, the work of Freund, Mendelsohn and Schmorl is of importance. They emphasize the frequent finding of shortening of the first rib and ankylosis of its sterno-clavicular joint in cases of lung tubercle. The consequent stenosis of the upper thoracic opening creates a tendency to the development of apical tuberculosis, as was first pointed out by W. A. Freund at the end of the fifties of the past century. The shortening of the first rib is owing to an abnormal shortness of its cartilage; this leads not only to constriction of the apex of the lung, but also to its insufficient aeration, since the shortened cartilage does not rise so freely during inspiration.

The treatment of this anomaly as proposed and also carried out by Freund consists in division of the shortened and ossified cartilage, an operation also performed by F. Kausch and by Seidel. According to the investigations of Hart and Harras, this abnormal shortness of the first ribs is seldom a primary, but usually a secondary development. These authors look upon it as a consequence of the very frequent skoliosis in the highest dorsal region, for which reason, as Harras

[1] See p. 177 *et seq.* for further description of these conditions.

states, the deformity of the thoracic opening is in most cases only on one side. This deformity of the aperture determines the condition they call "*Phthisical Thorax*" in contradistinction to "*Paralytic Thorax,*" which results from a weakly constitution, congenital or acquired, but in which there is no deformity of the opening present and consequently as far as that goes there is no special tendency to the development of tuberculosis. As in the former type the abnormality of the thoracic opening appears secondarily, prophylactic treatment of those individuals who have a tendency to it is more desirable than operative treatment of the deformity when fully developed.

As a result of the changes mentioned in form and position of the upper thoracic opening, it assumes an increased angle to the horizontal plane, the manubrium sterni stands lower and inclines backward, the upper part of the chest is flattened, with deepening of the hollows above and below the clavicle, while the ribs are inclined steeply down. In view of the flattening of the whole chest, systematic breathing exercises must be prescribed in good time, in order to strengthen the muscles of inspiration, especially those acting as elevators of the thoracic opening, a result to which incidentally lessons in gymnastics and in singing may contribute. This strengthening of the elevators of the thoracic opening is all the more desirable should premature or senile ossification of the cartilages have already taken place, in that it favours a fresh joint formation on the ossified cartilages. In these secondary changes in the thoracic aperture the apices of the lungs are also to be protected by breathing exercises from serious damage, and the earlier this is attended to the

better. The treatment of skoliosis is of the greatest importance in its bearing as mentioned on the origin of deformity of the thoracic opening, and its early discovery and treatment save the patient from more serious trouble, for, as is recognized, the more delayed the treatment of skoliosis is, the less is this favoured with success. Mosse found infiltration of the apices in fifty-three out of one hundred children with skoliosis in age from 5 to 16 years; Kaminer and Zade found apical affections in 75 per cent. of adult skoliotic women, while the degree of curvature corresponded to the severity of the disease of the lungs.

Among other causes of this high dorsal skoliosis *cervical ribs* sometimes find a place, and after what has been said above we need not be surprised that Nickol in Senator's Clinic should have discovered tuberculous apical affections on the same side as the cervical rib in unilateral cases, and in both apices in those with a cervical rib on each side.

This frequent coincidence of apical affections with changes at the upper thoracic opening necessitates especial care in drawing conclusions from the results of percussion and auscultation of a deformed thorax, both on account of possible change in position of the organs and of variation in the physical signs, which the altered surface contours may involve, considerations which Bäumler also has discussed. Since the percussion note sounds clearer and fuller over the flatter parts of the chest, and duller and emptier over the more rounded parts, it may come about that an apical affection may be mistakenly diagnosed at the supraspinous fossa on account of an increased curvature of the ribs produced by a high dorsal skoliosis of minimal degree,

causing an altered note, the misjudging of which would be avoided by recognition of the deformity present; *vice versa*, the supraclavicular fossa of the same side would give a clearer note than the opposite one, since the anterior portions of the ribs would be flattened. In a suspected case of this kind one should therefore subject both sides of the back to a careful orthopædic examination; one would see whether the neck-to-shoulder line stood higher or not with the patient in the upright posture, whether the corresponding shoulder-blade projected a little backward, and whether it was displaced upward or to the side somewhat away from the middle line. Then, with the patient bending forward and relaxed, one would look over his head and carefully inspect and compare the lines of the costal arches on each side of the spinal column; one can then decide on the existence of a skoliosis from a minimal difference in the contours, long even before a change in the line of the spinous processes of the vertebral column would show itself.

Pulmonary tubercle is a frequent coincident complication of *spinal caries;* Brenner has reported on a fairly large number of autopsies in which spinal caries, which remained clinically latent, was accompanied in most cases by tuberculosis of the lungs as well as of other internal organs. Pulmonary tubercle is much less frequent in *skoliosis,* according to Bachmann's statistics [1a], fifty-six times in 197 cases (28.3 per cent.); curiously the disease was found almost twice as frequently with slight deformities as with marked ones.

It should not be left unmentioned that Poncet (Lyons) has quite recently put forward a tuberculous origin for

[1a] Records of *post-mortem* examinations.

skoliosis, as he attributes the bony softening inducing curvatures to some previously active infection with tubercle. He found evidence of slight apical infiltrations in fifty-four out of eighty-nine children with skoliosis. Such children show an enfeebled state of nutrition, which points to latent tuberculosis; moderate enlargement of glands is frequently present and most notably intermittent albuminuria.

Apart from pulmonary tuberculosis, *emphysema* and *collapse* of the lungs, *pneumonia, bronchitis,* and *pleurisy* are to be recorded as further complications of spinal curvatures. In the statistics above mentioned, 274 out of 276 cases showed affections of the respiratory organs. Out of 197 cases emphysema existed in ninety-two (= 46.7 per cent.), bronchitis in eighty-two (=41.6 per cent.), pneumonia in forty-five (=22.8 per cent.). Out of 189 cases collapse was demonstrable in fifty-nine (= 31.2 per cent.), and compression in forty-six (= 24.3 per cent.). Emphysema, collapse, and bronchitis stand in close relationship to one another. The respiratory movements are often extremely limited in the deformed thorax, which remains fixed in the position of inspiration; the rigid state of the thorax may become such indeed that the diaphragm has to undertake the whole process of respiration. Apart from this causal factor of emphysema, the diminished power in expiration, there are the more important changes brought about in the lungs by the deformed thorax. The lung on the side of a dorsal convexity of the spine is compressed in the cleft-like space posteriorly, and it may also be compressed between the thoracic wall and the diaphragm. This compression of the lung determines a condition of collapse, which may also develop

now and then in other parts of the lung on account of the respiratory musculature being unable there to aerate the lung. The collapse may then in turn induce a compensatory emphysema in the vicinity. Emphysema, with the inevitably diminished elasticity of the lungs, and the obstruction to expiration involve disturbances of the pulmonary circulation; bronchitis from venous congestion ensues, and it may also result from obstruction in the course of the lymph vessels of the lungs. Hydrothorax is occasionally observed, while the chronic bronchitis adds to the risk of the occurrence of pneumonia.

Lesions at the surfaces of the lungs may implicate the pleura and be followed by pleurisy, be the exciting cause perhaps either the tubercle bacillus or the diplococcus of pneumonia. Conversely one may find a typical primary pneumonia or a streptococcal pleurisy infecting the vertebræ, and causing a spondylitis (Quincke). Pleuritic adhesions, which may be diffuse, as in the infections mentioned, or circumscribed, as from smaller foci of inflammation or infarcts of the lungs, are frequently found *post mortem* in skoliosis. Tuberculous pleurisy and peripleural inflammation, as also general miliary tuberculosis, are common complications of tuberculous spondylitis; and a risk to be apprehended is that of empyema which results from perforation of a mediastinal abscess in association with an acute infective osteo-myelitis of the vertebral column.

While pleurisy occurring secondarily in consequence of skoliosis has more interest from the point of view of pathology, it is necessary from the therapeutic standpoint to consider more closely the changes which pleurisy may bring about in the normally formed

thoracic wall. If a case of pleurisy with a large effusion or an empyema of long duration proceeds to recovery, it may be associated with a shrinking of all of one half of the thorax; the affected lung no longer fills up the whole of the cavity, and the mediastinum, the pleura, and the thoracic wall on that side approximate to one another. The occasional striking displacement of the heart to the same side (simulating dextrocardia in right-sided pleurisy) is described elsewhere. The spinal column assumes a convex curve toward the sound side, and contrary curvatures may be formed; one finds most commonly a *double* curvature, in which the upper dorsal portion is convex on the sound side, while the lower portion is convex on the diseased side. The ribs may touch and even overlap one another like slates, and possibly project inward to the thoracic cavity, so as to produce a trough-like indrawing of the affected half of the thorax. It is a feature of such skoliosis that there is no torsion produced, and the ribs on the convex, sound half of the thorax do not show any sharp bend at their angles, so that no hump on the ribs is developed. The shoulder is set lower on the affected side, and the last rib approaches the pelvis. On the affected side of the thorax the circumference is less and the respiration limited. The attitude of such a patient is characteristic, and the disease picture is known in French by the name of "*Rétrécissement thoracique*" (stricture of the thorax) (fig. 6).

In slight cases the deformity of the thorax is of no special significance, but it is otherwise in serious cases, when one considers, that, apart from the ugly deformity, the functioning of the lungs is very imperfect.

In skoliosis the main burden falls on the lung on the side of the concavity, but in this deformity it is impeded by the induration and cicatrization from efficiently responding to the call upon it. The pro-

Fig. 6.
Skoliosis consequent on empyema (after Lüning and Schulthess).

gnosis as to recovery from pleuritic or empyemic skoliosis is worse the older the subject of it may be. Methods aiming at preventing the occurrence of skoliosis go hand in hand with the surgical treatment of the causal

trouble. To cure the disease rapidly is to take early measures against the development of skoliosis. As Schede also states, the deformation consequent on the healing of an empyema stands in inverse ratio to the power of expansion of the lung and to the rapidity with which this is restored. The production of a deformity is guarded against most surely by just those methods which remove most satisfactorily the obstacles to the expansion of the lungs, that is to say, which most quickly put an end to all the inflammatory and exudative processes on the pleuræ, and the consequent formation of new fibrous tissue which later on contracts. Early tapping of large pleuritic exudates is therefore indicated if these are not speedily absorbed. If empyema is present, then, as Kölliker recommends, resection of rib should be performed in the posterior axillary line and as low as possible, to ensure good drainage for the pus. This authority never found skoliosis to occur in any case treated by resection of rib. But in addition gymnastic exercises for the thorax and lungs should be persevered with later on, to prevent skoliosis developing as it may do insidiously in the course of a year or two consequent on the retraction of the thorax. One must aim at restoring the natural condition by means of systematic breathing exercises and corrective exercises for the thorax.

Kölliker adopts the following procedure:—

"A sling to support the back of the head and the chin, as also hand-grips for self-suspension, are hung on pulleys from a frame with cross-bar. The height of the hand-grips can be shortened or lengthened at will. The grip for the hand on the affected side of the thorax is set so high that the arm must be raised up to seize it, while that for the hand on the convex side of the skoliosis is placed so low that the patient must stretch down to reach it. In

order to suspend himself, then, the patient must raise his arm high on the affected side, and he thus extends the thorax on that side, while he presses down with the arm on the opposite side and thereby corrects the skoliosis. To increase the effect, a broad elastic girdle is passed over the convexity of the skoliosis and attached to the vertical support of the frame on the opposite side. The patient maintains this position so long as his strength permits and repeats the exercise several times with a rest in between."

FIG. 7.

One can carry out such exercises also without special apparatus. The patient elevates his arm on the affected side, and places it with the elbow flexed over the top of his head. He lets the arm on the sound side hang down, holding a dumb-bell or some heavy weight in his hand, so that the shoulder on that side is dragged down. The patient now performs breathing exercises,

maintaining this position (fig. 7), in which the thorax is compressed on the healthy side and stretched out on the affected side. The respirations should be slow and deep, about twelve to the minute. When feeling slightly tired he takes a rest, to repeat the exercise presently. The duration of the gymnastics is suited to the constitution of the patient and the severity of his trouble, and they are repeated several times daily.

If one finds a skoliosis already fully developed, more active orthopædic remedies are necessary, and the fitting of a corset and the measures necessary for the active and passive remodelling of the spinal column call for consideration.

Diseases of the lungs themselves may also give rise to deformities of the spinal column and thorax in consequence of the defective respiratory activity, as is familiar to us in the typical sunken-in chest of the so-called phthisical habit.

While dealing with the diseases of the respiratory system, opportunity may be taken of referring to a serious affection, namely, **fat embolism,** which sometimes appears in association with manipulative correction of ankylosed joints or with open operations on the bones and after fractures. Its manifestations show themselves sometimes in immediate connection with the operation, sometimes only after some hours, or even days, the patient being well enough in the interval. They are caused by the escape of fat from the marrow into the circulation. At first the fat, which has been expressed from the marrow, settles in the capillary vessels of the lungs, but it may further be swept away from there and pass through the general circulation into the capillaries of various organs, giving rise to conse-

quent symptoms. According as the fat is held back in the lungs or passes thence to other organs, in particular to the brain, in which case striking features result, one may distinguish, following Payr, two forms of fat embolism: the *respiratory* and the *cerebral*.

In the *respiratory* form the mind remains clear almost to the fatal termination, the symptoms arising from the lungs being the most prominent, while the circulatory system is also involved. Occasionally the first sign of embolism shows itself during some operation on bone in a sudden cessation of breathing, accompanied by marked cyanosis. If the patient does not then die, there ensues very urgent dyspnœa (orthopnœa) with all the muscles of neck and thorax brought into action. There is often no change demonstrable by percussion. While auscultatory examination may be negative at first, later on, consequent on the impeded circulation in the lungs, one may detect fine or medium crepitations. If hæmorrhagic infarcts occur, the sputum contains more or less blood. The pulse is soft and irregular, usually with increased frequency.

In the *cerebral* form of fat embolism the mind is affected at an early stage. The patient may sometimes not recover consciousness from the anæsthetic. The pupils remain contracted and inactive, and a reaction is no longer obtainable. The eyelids remain open, and the eyeballs show constant rolling movements. Sensibility to pain is almost wholly lost. Chronic spasms of the limbs make their appearance, and one may notice spasms of the facial muscles. The mind becomes more and more clouded till passing finally into a state of coma lasting several hours.

As regards the lungs the symptoms are here not so

disquieting at first; only at a later stage do dyspnœa and cyanosis appear. The heart's action is usually accelerated from the first, and the pulse is frequently of low tension with a very small wave, and is occasionally irregular.

Rise of temperature is important, it may reach 40.5° C. (105° F.). Von Aberle considers it as a significant clinical symptom of fat embolism, and it may be attributable to the absorption of the fat.

A specially characteristic sign has been noted by Reiner in fat embolism. In all such cases examined he was able to demonstrate a *lowered level of the diaphragm* due to an increase in the volume of the lungs. Reiner adopts the view that in the embolized regions of the lungs the alveoli are fixed in a position of distension owing to the capillaries being filled with fat and the alveolar walls thus losing their elasticity.

The occurrence of fat embolism, as stated, is always associated with some injury of bone, trivial though that may be, which causes the introduction of fat into the circulation. A liability to this is shown by patients with atrophic bones, in which the deficient osseous tissue is replaced by marrow rich in fat, on which account, moreover, the bones are specially susceptible to injury. Atrophic bone conditions of this kind are found, for instance, in patients with congenital contractures or such as follow chronic polyarthritis or acute anterior poliomyelitis, in which cases the atrophy from disuse plays an important part, a condition consequent on the restriction or loss of power of movement in these patients.

As regards the last-mentioned paralytic contractures, one must endeavour accordingly by treatment to pre-

vent their onset; but if unsuccessful in this, one should operate early, before the red bone-marrow, containing little fat, is yet transformed in children into the yellow marrow, rich in fat, as takes place customarily at the age of 14 to 16 years. Most of the fatal cases of fat embolism occur in patients beyond this age.

In the presence of fat embolism the prognosis may be determined from the severity of the symptoms. Inhalation of oxygen is indicated for the relief of the dyspnœa, and also treatment to support the heart's action. Transfusion of saline solution has been recently recommended by Schanz [1b].

[1b] Schanz recommends that normal saline should be injected freely on the first appearance of symptoms. He considers that it greatly favours recovery by dilating the veins and dispersing the fat. Of his ten cases, nine got well. (*Centralblatt für Chirurgie*, 1910, No. 2).—Translator.

CHAPTER II.

Diseases of the Circulatory System.

As is the case with the lungs, so also the **heart** may be subjected partly to compression, partly to displacement, in consequence of spinal curvatures and the accompanying changes in the whole chest wall. The heart, indeed, presents some degree of adaptability to displacement, as is seen perhaps most strikingly in the excessive dislocation of the organ, which may result from the shrinking following pleuritic or empyemic exudates. The alterations in position of the heart are complicated by the changes in size of the lungs and the situation of the diaphragm.

In marked *skoliosis,* as we mentioned previously, the diaphragm is depressed rather than raised, but in addition it is also " inclined obliquely downward to the side of the greatest curvature of the spinal column " (Schulthess); for example, it is pushed up on the left side in a severe case of right convex skoliosis (fig. 8), and, of course, the position of the heart is influenced thereby. The lungs again in marked skoliosis almost always present changes which may similarly be of significance in clinical diagnosis in respect, for instance,

of altered position of the borders of the lungs from increase in their volume in emphysema, or of retraction from diminished volume in collapse. Diagnosis is made still more troublesome by the pathological changes which the heart undergoes in consequence of the embar-

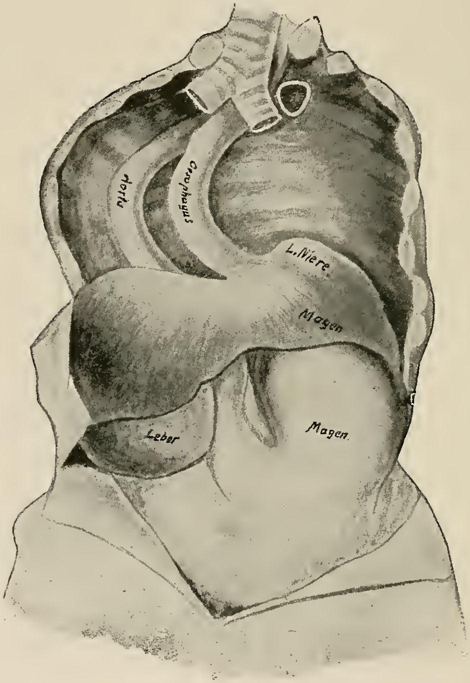

FIG. 8.

(After Nicoladoni.)

Magen = Stomach, Leber = Liver, L. Niere = L. Kidney.

rassment of the circulation, so that in a given case it may be uncommonly difficult to determine what the nature of the changes in the heart may be, whether rather of a mechanical kind due to the abnormal shape

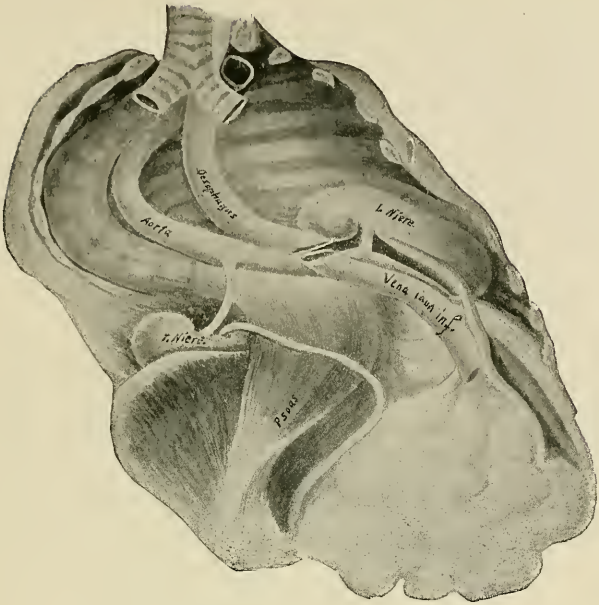

FIG. 9.

(After Nicoladoni.)

L. Niere = L. Kidney, r. Niere = R. Kidney.

The aorta lies in front of the vertebræ of the lumbar region which presents a marked left convex skoliosis. The right kidney is small, and is lodged in a deep recess within the concavity of the lumbar segment, behind and at the level of the crest of the ilium, lying almost horizontally with the hilum directed upward, and dependent from the elongated renal artery which crosses the spinal column transversely to reach it. It is cylindrical in shape and smaller than the left kidney. Its lower, here inner, pole is in contact with the upper border of the fan-like psoas muscle which presents a broad origin from the concavity of the lumbar segment, and over which the right ureter crosses transversely, appearing unduly long and taking a winding course till it enters the true pelvis. The left kidney is considerably larger than the right, presents a much broader hilum, is cylindrical in form, and is displaced forward as a whole out of its normal bed. The left renal artery arises at a distance of two vertebræ lower down than the right, springing vertically from the convexity of the aorta to enter the upper end of the hilum after a short straight course. The left psoas muscle is slender and spindle-shaped. The ureter passes along its inner border and takes a very winding course to reach the true pelvis.

of the thorax, or rather of a functional kind, as evidenced by an altered size of the heart.

Usually one finds the heart displaced to the left in right convex, and to the right in left convex skoliosis, but one cannot state this as a rule, since contrary conditions arise (Bachmann, Witzel), in which the heart is pushed over to the same side as the convexity. This state of things is found especially in left sided curvatures, in which the position of the heart seems to be less prejudicially affected.

In a case of tuberculous spondylitis with considerable humping the heart was found displaced so far downward that its apex lay at the level of the promontory of the sacrum.

The long axis of the heart may also be misplaced. It normally is diagonal, forming an angle of about 60° with the vertical diameter of the chest, but may come to lie in the horizontal plane. "This transverse position is a result of the shortening of the thorax vertically due to the marked projection inward of the spinal column" (May).

With shortening of the vertical diameter of the thorax the heart lies closer to the anterior chest wall, and with obliquity of the diaphragm is sometimes pushed upward.

The heart is also liable to deformation from direct pressure. In a case of Bachmann of spinal caries with kyphosis, the heart was very much flattened by the antero-posterior compression.

Careful consideration is as necessary with the less severe as with the marked deformities of the bony chest wall, to avoid false conclusions from the physical examination. Bäumler has pointed out that if the back

is flattened the intercostal spaces are often very wide in front, and the sternum is placed higher on account

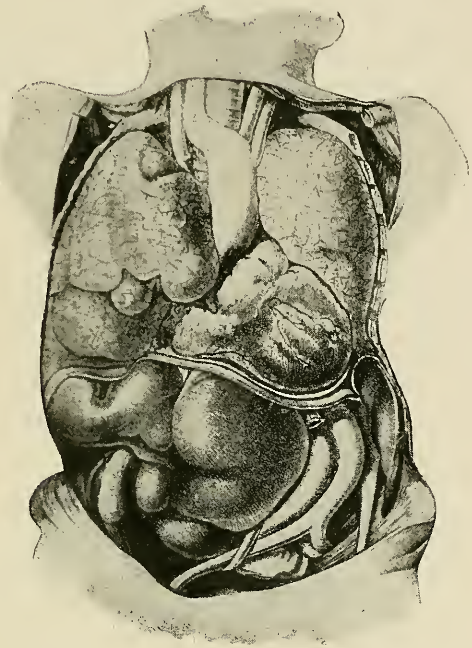

Fig. 10.

(Bouvier, after Bachmann.)

Skoliosis of the third degree, with specially marked lumbar convexity to the left, in a woman aged 69. The inner margin of the right lung is diminished in length as its lower part is compressed by the abdominal organs. The left lower lobe is crushed between the heart and the ribs. The large heart is closely approximated to the left ribs. The greatly deformed liver is divided up by deep furrows and rides upon the crest of the right ilium. The spleen is flattened out and pressed into the cleft between the convexity of the lumbar region of the spine and the left false ribs, and it extends down into the left iliac fossa. The inferior vena cava and the abdominal aorta follow the curvature of the vertebral column.

of the less oblique course of the upper and middle ribs, and the heart is in contact over a wider area of

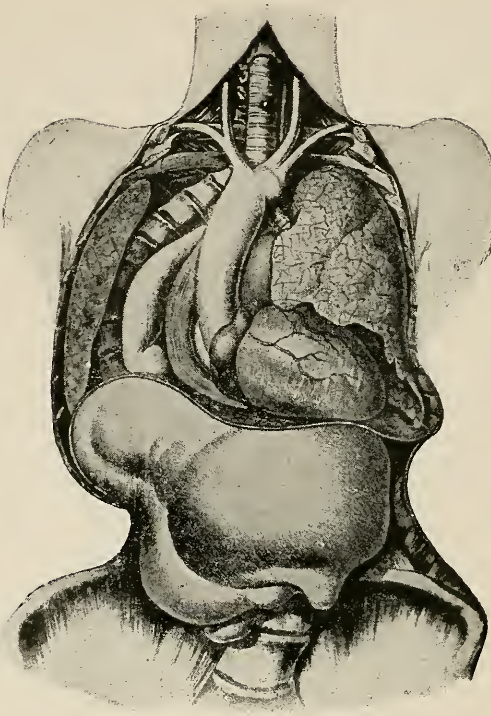

FIG. 11.

(Bouvier, after Bachmann.)

Skoliosis of the third degree, with dorsal convexity to the right, in a woman aged 65. Death from cerebral apoplexy. The right lung was greatly flattened by the transposition of the spinal column and the mediastinum toward the right half of the thorax. Its interior part has been removed in order to show the situation of the lung in the gutter formed by the approximation of the spine to the ribs. In this portion the lung tissue was solid and wholly devoid of air. The notably large liver takes up the whole breadth of the abdomen. The peculiarly shaped right lobe is tapered to the right and presents a deep furrow on its anterior aspect, corresponding to the compression produced by the cartilaginous arch of the ribs. In other respects the organ was normal. The thoracic aorta follows the concavity of the dorsal curvature and presents a somewhat marked kink in its lower portion. The œsophagus lies more to the left, but still shows a slight curvature in the same direction as does the aorta.

the anterior wall of the chest, owing to the diminished sagittal diameter. In consequence, the apex beat shows considerable increase in extent and intensity, even with a normal heart condition. The opposite is the case if the sagittal diameter is increased, as when the spine is kyphotic, and the heart may then be covered by the borders of the lungs.

If in skoliosis a normal heart is displaced forward to the left, the position of the apex may suggest a hypertrophy of the left ventricle, that is not really existent, just as in flat-chested conditions. M. Herz (Vienna) also utters a warning against making such misinterpretations of the signs, which is of the greater significance, because true *functional* disturbances of the heart are found in people who adopt habitually a faulty posture of the body. If a person assumes constantly an attitude in which he bends forward and to the left, as one sees, for instance, in clerks, draughtsmen, and especially in dentists in connection with their professional work, it may result in such a cramping of the left side of the thorax in all three dimensions, that the heart is prevented from acting freely, and this finds expression first of all in functional, and later on, perhaps, in more serious disturbances of the circulation. It is important in such cases to have in view this likely cause of heart affections and to correct the faulty bodily posture, and, if present, the spinal curvature, with the aid of suitable orthopædic treatment, such as breathing exercises principally, and also massage and gymnastics for the musculature of the back. As preventive measures one must ensure that these patients adopt at their work a correct posture as far as is possible.

The plan adopted by Herz is to make the affected individual use a high standing desk for clerical work in place of the ordinary writing-table, and sit astride a high stool instead of using the ordinary chair. When sitting on a high stool, the thighs sink almost straight down, and the pelvis is inclined forwards. A lordosis of the lumbar region results, and the convexity in the dorsal region is straightened out. If the patient under these conditions still tends to assume his customary habit of bending to the left, letting the right elbow rest while the left one hangs down, one may have in addition a bracket, a few inches in breadth, attached to the left side of the desk projecting out from it to furnish a support for the raised left arm.

One of Bachmann's cases shows that the heart may escape harm in even the worst cases of spinal curvature. This was a patient who had attained an age of 86, and the heart showed no evidence of damage at all. As a rule, however, some form of the various disturbances of the circulatory system is found. According to Bachmann, out of 276 cases, 251 (= 91.3 per cent.) had affections of the circulatory apparatus, and of these 247 (= 89.5 per cent.) had affections of the heart or pericardium. Of these, forty-one presented valvular disease of the most varied character. Perforation of spondylitic abscesses into the pericardium was rare. *Hypertrophy* and *dilatation* of the heart was a common finding, the right side of the heart being specially subject. Out of 154 cases, eighty-seven (= 56.4 per cent.) had hypertrophy and dilatation on the right side, twenty-seven (= 17.5 per cent.) on the left side, and forty (= 25.9 per cent.) on both sides of the heart. About half of the cases of hypertrophy and dilatation were caused by severe affections of the vertebræ.

If the heart suffers for a long period from disturb-

ances of compensation in consequence of which oxygenation is interfered with, it necessarily suffers from the impoverishment of its blood-supply and there develops a *degeneration of the myocardium* with its sequences.

The cardiac affections mentioned, in addition to the displacements described of the heart itself, and the lesions simultaneously occurring in the lungs (emphysema, collapse) all contribute to making the physical diagnosis a matter of difficulty. The *apex beat* may be often neither visible nor palpable on account of the emphysematous lung, but otherwise is usually to be made out in the fourth and fifth, rarely in the third, intercostal space, situated between one to two fingers' breadth within the mammary line, and one to two fingers' breadth outside of it (Bachmann, Wullstein-Reineboth). Its area is frequently enlarged. The *right border of the heart dullness* lies between the left and the right parasternal lines; the upper limit between the second and the fifth ribs; the *left limit of dullness* is sometimes found at the left margin of the sternum, on account, it may be, of the heart being so much covered by lung, or of its actual displacement to the right side (Bachmann).

As for conclusions to be drawn from auscultation, the possibility of kinking or displacement of the aorta must be kept in mind.

Hypertrophy and dilatation of the right ventricle, as before mentioned, are for the most part brought about by the obstruction to the pulmonary circulation, consequent on emphysema and chronic bronchitis; but in addition we must recognize, in agreement with Schulthess, the part played in this respect by the

diminished respiratory movements, which factor puts an extra strain on the work of the heart, especially on its right side, in the endeavour to oxygenate the lungs efficiently. Similar pathological manifestations on the left side of the heart may be associated with displacement or kinking of the aorta.

Just as deformities of the thorax have an effect on the heart, so may, conversely, certain diseased cardiac conditions induce some changes in the thorax. Enlargement of the heart or distension of the pericardium from effusion often leads to a very striking bulging of the præcordia (Germ., *Herzbuckel;* Fr., *Voussure*), especially if occurring in young persons. This bulging evidences the attempt of the heart to enlarge the left side of the thorax. This unequal alteration in the form of the chest acts upon the spinal column and produces a skoliotic deformity, which according to Chr. Lange presents a characteristic type with a right convex curvature extending from the first to the ninth dorsal vertebra. The observations at first-hand, made by Schulthess, would show, however, that there is so far no ground for ascribing a special type of skoliosis to this condition.

The **aorta** is bound down to the left side of the vertebral column by its intercostal and lumbar branches and by the vessels crossing it (especially the splenic and left renal veins), as well as by connective tissue. It therefore tends to follow the spinal column in its curvatures, but only so far as the shorter intercostal arteries of the left side permit. As these, almost immediately after their origin, penetrate the soft parts of the left intercostal spaces, they are fixed there and do not admit of being stretched out. It is otherwise

with those of the right side, as before they become fixed in the intercostal spaces, they cross the bodies of the vertebræ, in which extent of their course they are less fixed. The aorta is therefore compelled by anatomical reasons to retain, if possible, its left-sided position, as may be seen, for instance, in the more acute curvatures to the right side. According to the opinions of Bouvier and Bachmann, who have drawn fully on previous literature and their own observations, the aorta is drawn almost imperceptibly to the right in slight cases, and quite distinctly to the left in cases of medium severity of spinal curvature. In very marked skoliosis it may come to lie eventually on the heads of the left ribs or be displaced even further to the left. The unyielding nature of the aortic attachments which bind it to the spine, may cause the aorta, even in the right convex curvatures, to appear to occupy its normal relationship or even displace it across the middle of the bodies of the vertebræ toward the right. Further down in its course, where the right convex curvature passes into a left convex lumbar curve, the aorta crosses the middle line of the vertebræ and comes to lie on their anterior surface, or even a little to the right of the lumbar vertebræ when these are markedly skoliotic. The displacement of the abdominal aorta in this region is not so great, as it is less fixed.

In the less common left convex dorsal curvature the thoracic aorta is less subject to displacement, even in severe skoliosis. Exceptionally the aorta is found on the anterior aspect, or even on the right side of the spinal column. Lower down, in the region of the right convex lumbar curvature the aorta commonly lies on

the anterior or left anterior aspect of the vertebral column.

In skoliosis the curvature of the aorta may frequently result in distinct angularity, though, it may be, not presenting such an acute flexion as may follow on tuberculous spondylitis. Bachmann has seen in skoliosis such a severe kink in the aorta as to cause a definite fold projecting into the lumen. In rare cases aortic aneurism may develop; Schulthess also describes an aneurismal dilatation proximal to a kinked portion of the aorta.

In tuberculous spondylitis the aorta is threatened by two dangers; firstly, abscesses in connection with the vertebræ which sometimes lead to erosion and perforation, secondly, sharp kinks to which it may be subjected when a hump forms. It is exposed to these two dangers, since its fixation to the vertebral column on the one hand prevents its escaping from the proximity of an abscess, and on the other hand involves it in the sharp angle of the spine. Thus it has slight chance of accommodating itself to the bend in virtue of the elasticity of its walls or by means of some displacement. The distortion may present a manifold angular flexion or a bayonet-like form, and the consequent hindrance to the circulation of the blood may result in serious damage to the heart and to those parts of the body deprived of proper nourishment. Lannelongue finds in this a possible explanation of sudden paresis or paralysis of the lower extremities.

The **superior** and the **inferior vena cava** are at the most but slightly altered in position, since they are relatively loosely fixed to their surroundings. But at

those points where the vena cava is more or less firmly fixed, as in the region of the liver, at its passage through the diaphragm, at the right auricular sinus, and perhaps in the region of entrance of the renal veins, one may find there even considerable alterations in the course of the vessel in cases of marked skoliosis, as Bachmann points out. In severe right-sided dorsal skoliosis, with the heart displaced to the left, one may accordingly find a kinking of the vena cava, which is of clinical importance, at the diaphragm or at its auricular junction, which is to be accounted for by the vein, in its upward course from left to right, being able only by making a sharp bend to reach the heart, displaced to the left.

In tuberculous spondylitis the vena cava is threatened much less than is the aorta by vertebral abscesses or by danger of kinking, since, thanks to its loose attachments, it may be pushed aside in abscess formation, and may adapt itself in angulosity of the spinal column by assuming a serpentine course.

The **azygos vein,** unlike the aorta, is only loosely fixed, and usually follows the concavity of the curvature. The **thoracic duct** remains, as a rule, on the anterior aspect of the spine.

CHAPTER III.

Diseases of the Digestive System.

THE relations of the **œsophagus** in spinal curvatures have been studied most fully, first by Hacker and Bachmann, and later by Jawin also. Hacker found that in *skoliosis* the course of the œsophagus is not influenced by marked lateral curvatures in the same degree in all cases. Generally speaking the œsophagus tends to be inclined toward the concavity of the fully developed curvature. But the influence of the lateral curvature on the œsophagus is usually slight, and it never follows the course of the spinal curves in their entirety, as does the thoracic aorta; and this is so much less the case the more rounded the curve may be and the lower down the secondary curvature beneath the diaphragm may form.

In its *cervical* portion the œsophagus accompanies the antero-posterior movements of the spine. Inclination of the head forward causes expansion of its upper orifice, and inclination backward causes constriction by the backward pressure of the cricoid. Similar effects are thus produced by *kyphosis* and by *lordosis* respectively of the cervical vertebræ. Stoerk has described

dyspnœa and dysphagia caused by an extremely marked cervical lordosis. In such a case the posterior wall of the pharynx may be so projected forward that any inspection beyond it of the lower parts of the isthmus of the fauces or into the larynx is made impossible. The most prominent part of the forward projection is commonly at the body of the fourth cervical vertebra, which lies approximately at the level of the posterior wall of the larynx. At times this aggravated cervical lordosis is situated rather lower, corresponding to the fifth, sixth, and seventh vertebræ, and may by compression of the œsophagus cause difficulty in swallowing. Such dysphagia may be relieved in some cases by the application of a high stiff collar, which serves to extend the cervical spinal column.

In the *thoracic* region the œsophagus does not follow the antero-posterior curves of the vertebral column, but passes somewhat straight down, though it may occasionally adapt its course closely to the spinal curvatures (Bachmann). Hacker states that he found " in a case of curvature with the convexity to the left in the lower cervical and upper dorsal regions, and to the right in the middle and lower dorsal regions, in which the œsophagus lay in the left half of the thorax which was broadened transversely, that the lower end of the œsophagus was widened considerably and passed into the stomach without any distinct narrowing at the cardia. In view of the loose connection between œsophagus and vertebræ, one cannot say that as a rule the former follows directly the curvature of the latter, but at any rate it is often so closely applied that it may be indented by any specially prominent vertebræ, and it

may be subject to kinking or constriction by the left bronchus at the bifurcation on which it rides, so to speak, and also to some traction from this source toward the side of the convexity. It may further be pushed in this same direction by the greater development and extension of the organs in the transversely widened part of the thorax on the side of the concavity. In the lower part of the thorax where the œsophagus normally inclines forward from right to left, it may present such a flexion in the interval between the limbs of the curvature of the spine as to form an angle open to the front." In cases of very marked skoliosis with two compensating curvatures in the dorsal region the œsophagus may be often correspondingly curved, and may show, moreover, an additional flexion from before backward. It should be stated also that the cardiac hypertrophy not infrequently associated with curvatures is not without influence on the œsophageal tube, as the heart, if enlarged, will push it backward and to the right and constrict it.

But the effect on the course of the œsophagus is much more striking in vertebral curvatures, when, as the result of some pathological process, the loose connective tissue lying behind it is rendered unyielding, as may occur in presence of advanced pulmonary tuberculosis or of similar disease of the mediastinal glands (Jawin). Adhesion of bronchial glands to the œsophagus, moreover, may cause dragging on it and give rise to the formation of traction diverticula.

In *spinal caries* the œsophagus, thanks to its loose attachments, may maintain its normal straight course, bridging the angular curvature like the string of a bow. If, however, the kyphosis develops very rapidly the

œsophagus now and then may be unable to escape kinking, as it is able to do in slowly developing deformity, in virtue of its contractility. Similarly the œsophagus undergoes the same angular curvature as the spine, should it become adherent to it as the result of the carious inflammation of the vertebræ, in which case it is liable to perforation (Penzoldt). Tuberculous abscesses, too, originating from the vertebræ, may displace the œsophagus or burst into its lumen, as similarly into the trachea. Occasionally one finds a bagging of the posterior wall of the œsophagus, a sort of traction diverticulum (Meinel, Wolzendorff), at the level of the spinal angle, consequent on cicatricial union of the œsophagus with the prevertebral connective tissue.

The **stomach** is not displaced to any notable extent in the slighter degrees of spinal curvature. In severe cases of right convex dorsal skoliosis the liver, alike under pressure, pushes the stomach downward to the left, in which case it assumes a more vertical position, or it may be displaced down as a whole so that its greater curvature reaches almost to the sacral promontory or the symphysis. In a case of Schulthess a constriction was produced by the pressure of the ribs.

The commonest complications here of severe spinal curvatures are chronic *gastric catarrh* and *hæmorrhages,* attributable to the marked chronic venous congestion. Bachmann found affections of the stomach in 36.5 per cent. of the cases.

The **intestines,** being the most yielding of the abdominal contents, are crowded by the other organs in the direction of least resistance. In a case, for example, of severe right convex dorsal skoliosis, the right half of

the abdomen is occupied by the liver, cramped as that is by the lateral displacement and flexion of the thorax, leaving no room for the intestines, which have to find accommodation on the left ilium and within the pelvis. In particular the transverse colon may be so displaced that it passes obliquely or vertically from above downward, almost at right angles to its normal course.

The intestines are subject to *catarrh* and *hæmorrhage,* similarly to the stomach and with almost equal frequency, and *ascites,* also due to chronic venous congestion, is a frequent occurrence.

There is a diagnostic point of great importance in respect of the "pain in the belly" which now and then is complained of by children, who, bright and lively but shortly before, have become all at once cautious in their movements. Such abdominal pains often get worse after meals, and at times there are seizures of colic-like pains. The frequency with which the stomach or bowels may be out of order in children may lead the physician in attendance to diagnose some such disturbance, in the absence of other obvious symptoms, and to treat the supposed trouble accordingly. Only when the pain goes on increasing in spite of the most careful treatment does doubt arise, and then a comprehensive and repeated examination brings to light the first objective signs of a commencing *tuberculous spondylitis.*

This shows itself as follows: The child walks with a peculiar stiff carriage of the whole trunk, and the youthful elasticity normally present is evidently lacking. If he happens to bend down, he does not raise himself up readily again, but supports himself in doing so with the hands on the thighs. The spastic fixation of the

spinal column, which is the cause of the stiff restrained gait, is due to the endeavour of the child to maintain the diseased part of the spine as much undisturbed as possible. The physician can base a correct diagnosis on the detection of this spastic muscular fixation (fig. 12) [2] much earlier than the more prominent objective signs of spinal caries show themselves, such as the commencing humpback, abscesses, or, it may be, secondary disturbances of the central nervous system.

These abdominal pains in the child with vertebral inflammation are, of course, not to be controlled by morphia, opium, or other symptomatic remedy. Only by fixing the diseased spine as speedily as possible does one come to the relief of the child, which is instinctively striving to attain the same result. A properly applied plaster-of-Paris bed or plaster corset will put an end, as if by magic, to the persistent distressing pain [2a]. If this remedial measure is not at once available, a firm bandaging of the trunk provisionally with a towel, a sheet, or with bandages is of service, especially if one stiffens and makes firm the bandage with strips of veneer-wood, pasteboard, or the like, put in between the layers.

The **spleen** is frequently placed abnormally high, but again on account of its mobility it may be pushed down by other organs or frequently also by the depression of the diaphragm. Among the abdominal viscera, it is the least subject to alterations of shape, but one sometimes observes marks impressed on its surface by the bodies of the vertebræ or by the ribs. The commonest

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[2] See p. 50.

[2a] See footnote on p. 165 for description of the plaster bed and its application.

affections found in the spleen are *atrophy, chronic venous congestion, perisplenitis,* and *cyanotic induration.*

The **liver,** next to the lungs, is most liable to deformity. It is for the most part placed lower down and beyond the costal margin, if the diaphragm is depressed. The downward displacement of the liver is still more evident when it is subjected to direct pressure on its upper aspect by the bodies of the vertebræ in cases of spinal curvature low down on the right, when often it may be crowded into the false pelvis. It may also show various forms of torsion. In right convex skoliosis the lower margin of the twisted thorax may press deeply into the liver and cause furrows (Lorenz). Horizontal grooves may be impressed on both lobes of the liver, or perhaps only the lower portion of the right lobe. In the latter case a portion of the liver may be so cut off that in the course of time there remains only connective tissue containing blood-vessels and bile-ducts at the constricted part, so that eventually a pedicle is formed with a freely mobile mass of liver attached to it. Just as the ribs may cause deep grooves —Bachmann found up to five such on the surface of the right lobe—so may also the spine and the upper pole of the right kidney leave their mark on the liver. The right lobe is frequently smaller than the left, and occasionally, especially with marked right-sided lumbar skoliosis, one finds the right lobe, not much bigger than the fist, pressed firmly into the hollow of the spinal curvature (Bachmann). Left convex curvatures have less prejudicial effects on the liver.

Passive hyperæmia and its sequences are found in the liver, as in the spleen, as pathological developments, and often also adhesions to the surrounding tissues.

The outward appearance of the abdomen, as may be mentioned here, undergoes a striking change of contour when there is any considerable shortening of its vertical diameter caused by a marked lumbar or dorso-lumbar kyphotic skoliosis, or still more frequently by lumbar angular curvature. In such circumstances a transverse fold, of perhaps considerable depth, is developed in the skin in the region of the umbilicus (figs. 19 and 32). In consequence of the retention of the skin secretions the opposing surfaces become gradually eczematous and painful. To relieve the resulting discomfort in such cases mechanical treatment is called for.

CHAPTER IV.

Diseases of the Urinary System.

THE **kidneys** are liable to be seriously involved in the presence of marked spinal curvatures. As these organs are somewhat firmly fixed, the changes they show are the more definite. The kidney on the side of the convexity of the curvature lies lower down, that on the side of the concavity lies higher.

The kidney on the convex side may be very much cramped, as the lower portion of the thorax, being closely approximated to the spine, may leave only a cleft-like space available for the kidney (Bachmann). In this case the organ is either smaller as a whole, or else it is flattened out. The kidney on the side of the concavity then undergoes a compensatory hypertrophy and becomes more rounded or cylindrical. There may, however, be a converse state of affairs. O. Israel has described the findings in a case of marked curvature of the lower dorsal and lumbar regions to the left side —the right convex dorsal skoliosis is much the commoner—in which the right kidney was found to lie in its approximately normal position at its usual level,

whereas the left one was displaced downward on to the left ilium with about 2 cm. of its length projecting into the true pelvis. The renal vessels had their normal origin, but the artery and the vein both took an almost vertically downward course on account of the low situation of the kidney. It was found that a sound passed into the ureter formed an excessively small acute angle with a sound passed into the renal artery, whereas these two structures normally cross at a right-angle. The left suprarenal body, considerably elongated, lay at the upper end of the kidney. The left kidney was of approximately normal size, but pyonephrosis was present in conjunction with perinephritis. It was not a case of a floating kidney, but of a fixed dislocated one.

The kidney on the side of the concavity may now and then show slight changes of shape. The worst harm results when the kidney lies embedded in a deep niche formed by the curvature of the spine and the psoas muscle, and the ureter is consequently constricted when the psoas, over which it passes, goes into contraction. Hydronephrosis then results from the hindrance to the passage of urine.

Chronic venous congestion of the kidney, with its sequential developments of *interstitial nephritis, granular contraction,* and *cyst formation,* is a frequent finding in association with severe curvatures of the spine. Bachmann found some pathological change in the kidneys in 132 out of 197 cases (= 67 per cent.).

In 1890, Heubner called attention to a special type of albuminuria and to the significance which the erect posture of the body, or more correctly the assumption

of the upright after the horizontal attitude, had for that condition. Since then the subject of *orthostatic* or *orthotic albuminuria* has been thoroughly studied, principally by specialists in diseases of children. On the basis of comprehensive observations and experiments, Jehle has now come to the conclusion, that in orthotic cases it is *not the upright position in itself* which determines the origin of the albuminuria, *but a coincidently occurring lumbar lordosis.* Jehle finds support for his view in that, given a natural recovery from, or an artificial correction of, the lordosis, the albuminuria is respectively absent or is inhibited; and in that even a slight correction of the curvature suffices to prevent the albuminuria developing. He was able to induce the albuminuria experimentally, by producing a lordotic curving of the straight or slightly kyphotic spine, and he could prevent the occurrence of albuminuria if the patient was fixed so as to oppose the assumption of the lordotic position. No excretion of albumin takes place during walking or running, as then the lordosis is abolished, chiefly by the forward swing of the leg when walking, and by the forward bending of the body when running; on the other hand, however, albuminuria almost always occurs when marching as on parade, as in such circumstances a position of forced lordosis is adopted. Sometimes it is only with an exaggeration of the lordotic posture that albumin is excreted.

As the albuminuria also occurs when the patient is *lying down*, if kept in a position of lordosis, Jehle concludes from this that it is not really orthostatic in origin and that the lordosis must stand in causal relationship to the albuminuria. His view is that the

functional disturbance of the kidney is due to the forward arching of the lumbar spine, with its greatest prominence at the first or second lumbar vertebra; consequently a passive hyperæmia is set up by disturbance of the renal circulation, as the renal veins discharge into the inferior vena cava at that level. Lordotic albuminuria takes place also in individuals with perfectly healthy kidneys. As a rule, one has to deal with children with some weakness of the muscular system at that age when the spinal column is growing most rapidly in length, that is to say, from the sixth year to the end of puberty. Not without some bearing on this, perhaps, is the fact that in children from the eighth year onward the natural lordotic curve in the lumbar region of the spine is being specially developed, while the kyphotic curve in the dorsal region is diminishing or at least not further developing (Schulthess).

Jehle's views have not remained undisputed. Changes of nervous, cardiac and renal nature have been held responsible for the orthotic albuminuria, based on the idea that a diminished and altered functional action of the vasomotor system is brought about by the transition from the horizontal to the vertical posture, thus causing a reflex arterial anæmia of the kidneys (Chvostek, Stejskal, G. H. Lemoine and G. Linossier).

The outcome of these observations is that cases of orthostatic albuminuria at the age of puberty are almost equally as commonly found with as without lordosis, and also that, on the other hand, lordosis may exist without albuminuria (Chvostek, Stejskal, Vas). Even if orthostatic albuminuria is not generally recognized as being lordotic in origin, yet the fact

remains that in special cases the suppression of a lordosis puts an end to the albuminuria [2b].

To correct the lumbar lordosis we employ mechanical means, making use of the pelvis to obtain this object. As the lordosis and the degree of tilting of the plane of the pelvis are proportional to one another, it is thus possible to diminish the lordosis if the pelvis can be effectively elevated. Preleitner has endeavoured to attain this with the aid of a special apparatus.

This consists of a girdle round the pelvis, carefully modelled to it, and a flat pad, which is placed above the lordosis below the shoulder-blades. The pad is firmly attached to the girdle opposite the sacrum by two strong unyielding steel bars which are inclined forward. When the pelvic girdle is applied and prevented from slipping by means of two straps passing round the thighs, the upper part of the trunk is pressed forward by the pad above the lordosis. The patient cannot then straighten the upper part of his body, on account of the resistance offered by the pad, otherwise than by further extending his thighs at the hip joints. By doing this, however, the pelvis comes to be placed more horizontally, thus diminishing the lordosis.

If instead of using such apparatus one should wish to apply a corset, this should be built up on the basis of a pelvic girdle firmly secured by straps round the thighs. The model for the corset must be taken with the body in a position which ensures a lessening of the lordosis, and the chief strength is accordingly required in the busks at the back.

A plaster-of-Paris corset will serve the same purpose, and should be applied to the child sitting, in a position,

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[2b] See also in this connection an interesting discussion on "The After-history of Cases of Albuminuria in Adolescence," in the *Proceedings of the Royal Society of Medicine*, 1911, vol. iv, No. 7. Medical Section, pp. 109-146.—Translator.

therefore, of dorso-lumbar kyphosis. In hospital practice one has probably to be satisfied with a corset, not removable, of this kind.

While we have previously described the influence of spinal deformities on the kidneys, it must not be forgotten that conversely the kidneys may have effect on the spinal column. Observations of this kind were first recorded by Gibney, in 1876, who met with two cases of dorso-lumbar skoliosis, which developed in connection with perinephritic abscesses.

Paulet and Bloch have observed analogous cases with renal calculus, and Besson with perinephritic abscess.

Dieulafé had a patient, a woman, aged 25, who suffered from a floating kidney on the left side and attacks of pain due to hydronephrosis. This patient presented a left convex lumbar curvature, which had completely disappeared three weeks after the operation of nephropexy. Kirmisson observed the disappearance of a deviation in the spinal column after recovery from nephritis, while Rédard noted the appearance of such deviations following on contusion of the kidneys.

Zesas also has treated with success a curvature of renal origin. All these skoliotic conditions of renal origin—not of "nephritic" origin as Zesas describes them, since other affections of the kidney besides nephritis may cause them—involve the lumbar or dorso-lumbar region of the spinal column. The term skoliosis is applicable to these deviations from the normal only in so far as one cares so to describe the lateral inclination of the spinal column, for these are in reality constrained positions produced reflexly, and they disappear after recovery from the trouble in the kidneys. For

the like reason they vanish in the state of anæsthesia. The pain sets up a muscular contraction on the healthy or on the affected side and causes there a curvature of the spine. As in the case of skoliosis due to sciatica, one distinguishes homologous and heterologous deviation, according as that develops toward the affected or the sound side respectively.

FIG. 12.

In regard to diagnosis, a word of warning is necessary against confusion with spondylitis. In skoliosis of renal origin there is no tenderness of the bodies of the vertebræ on pressure, and the spine is freely movable, in contrast to spondylitis. The pain present is referred to the side of the spinal column in the region of the kidney. The differential diagnosis of these two conditions is the more important, as in spondylitis also

abscesses may be met with close to the kidney and in the pelvis (Brenner).

As a further complication in diagnosis is the fact, to be kept in mind, that there occur cases of early spondylitis presenting no angular curvature or gibbosity, but a skoliotic posture (fig. 12), and that patients with lumbar spondylitis in an early stage, presenting no gibbous prominence, may complain of severe attacks of pain which radiate to the region of the bladder or the point of the penis, thus rousing a suspicion of the existence of vesical calculus, so that, for instance, in one case the bladder was opened on the basis of this false diagnosis (Hoffa). The bladder, however, may be affected in reality, as by the rupture into it of an abscess gravitating downward.

CHAPTER V.

Diseases of the Nervous System.

I.—Diseases of the Peripheral Nerves.

Paralytic Affections.

Paralysis of the **Phrenic Nerve.**—Lesser (likewise more recently Murk Jansen), who holds the view that inequality of respiration in the two halves of the thorax furnishes a cause of spinal curvature in early life, has attempted to settle the question by animal experiment. He accordingly divided the phrenic nerve on one side in young rabbits.

When the phrenic was severed on the *right* side there developed in the majority of the cases a *left convex* lumbo-dorsal skoliosis, with contrary curves above and below. When the *left* phrenic nerve was divided the skoliosis, as a rule, was *right convex* dorsal with corresponding contrary curves above and below the principal one; but this state of affairs was by no means invariable in every case.

P. Moritz has noted that a patient with a traumatic paralysis of the phrenic had also skoliosis, the origin of which from the paralysis was quite possible, but

did not appear certain, since the slight skoliosis might be considered as an accidental finding not previously recognized.

Tuberculous disease in the upper cervical spine stands out among the affections of the vertebræ and meninges which may bring about paresis or paralysis of the phrenic nerve. Paralysis of the phrenic is, however, a rare complication of spondylitis, and occurs when damage is done to the third and fourth cervical roots.

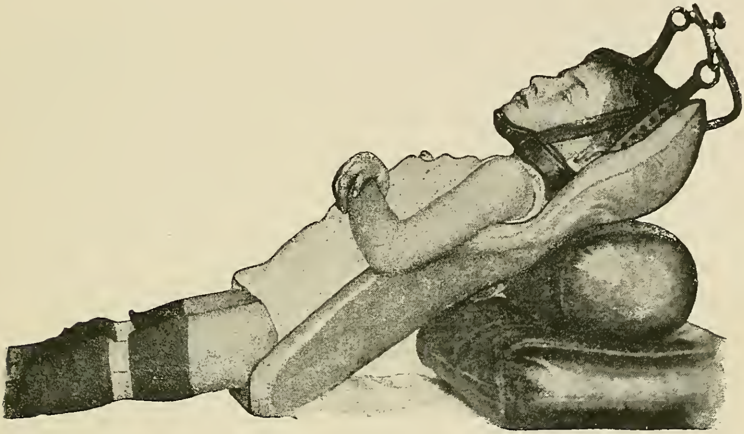

FIG. 13.

While we should treat spondylitis in this region by means of a supporting collar, by bandages or by a plaster-of-Paris bed with extension, according to circumstances, we here use the *plaster bed with extension* [3] (fig. 13) exclusively, as consideration must be given not only to the treatment of the vertebral caries, but also to the general principle involved in dealing with

[3] See pp. 165-6 for particulars of this.

a paresis of the phrenic. Patients so affected must maintain an undisturbed position in bed and avoid all unnecessary exertions, even that of speaking (Bernhardt). The plaster bed with extension fulfils both these requirements; it relieves the pain caused by the spondylitis, favours the recovery from the inflammatory processes which give rise to the paralysis, and ensures to the patient at the same time a safe position at rest.

Paralyses in the region of the **Brachial Plexus.**—The condition of *obstetrical palsy* takes a prominent place in the paralytic affections of the brachial plexus. As far as the manifestations of paralysis are of purely nervous origin they do not present anything unusual. The types are familiar, namely, the *Duchenne-Erb* or *upper plexus paralysis,* involving the deltoid, biceps, brachialis anticus, supinator longus, supinator brevis, and infraspinatus, as well as other muscles, and the *lower plexus paralysis* or *Klumpke* type. In the latter there is presented an appearance just as typical as in the Duchenne type, and consequent on the paralysis of the small muscles of the hand and forearm, with at the same time disturbances of sensibility in the region of the ulnar nerve, as also on the inner aspect of the upper arm and forearm. While the paralysis affecting the lower part of the plexus is a much less common eventuality than the upper type (Stransky), still less frequently is *total paralysis* of the plexus found as a consequence of trauma at birth. In these severe cases it is the rule to find some coincident injury to the shoulder girdle. In such connection may be mentioned dislocation of the shoulder, fracture of the acromion, or of the clavicle, especially, however,

separation of the epiphysis of the head of the humerus, or, more accurately, the wrenching-off of the cartilaginous portion of the upper end of the humerus from the bony shaft. Although these injuries to bone are almost constantly present in severe cases of plexus paralysis, that is not to say that they may not occur in the slighter forms of paralysis, and they may indeed be found without any injury to the nerves being demonstrable. This last form of "obstetric palsy" does not really belong to the types of paralysis, being merely a deformity of the shoulder brought about by a skeletal injury, which, however, cannot be wholly separated from the other groups in view of the secondary effects produced in the musculature of the shoulder.

The causation of this injury at the birth of the child has been studied very fully by Küstner. If, during the manœuvres of delivery, the upper end of the humerus of the child is subjected to pressure from above and behind, or from below through the axilla, there may ensue a loosening of the attachment at the flat, and therefore somewhat weak, epiphyseal junction of the diaphysis with the cartilaginous epiphysis. Should the attendant at the delivery then twist the arm at the shoulder beyond the normal limits, a complete separation of the diaphysis will result. According as the dislocating force is applied from above and behind or through the axilla the end of the diaphysis will pass respectively downward and forward, or else upward and backward.

(It may be mentioned in passing that the projection of the broad end of the diaphysis through the periosteum can often be mistaken for a dislocation of the shoulder-

joint. Küstner has emphasized that, owing to the weakness of the epiphyseal junctions, separation of the epiphysis in the newly born child is the outcome at all joints, including the shoulder, of injuries which in adults would give rise to dislocation.)

Given a diastasis at the upper end of the humerus, then the epiphysis is rotated outward by the muscles inserted into it, the supraspinatus, infraspinatus and teres minor, while the diaphysis undergoes inward rotation due to the teres major, latissimus dorsi and pectoralis major. If now the injury is not recognized, or else not suitably dealt with, the fragments unite in a bad position, the head of the bone is fixed in permanent outward rotation, the shaft similarly in inward rotation, and the muscles of internal and external rotation involved remain contracted. Since the position of the head is not manifest and only the internal rotation of the upper arm is obvious, such a condition may be mistaken for one of paralysis of the external rotators of the arm, which is not the case, for these muscles, as also the internal rotators, are actually in a state of contraction almost to the limit of their capacity. Reduced to inactivity, these muscles then become atrophic, and thus the resemblance to a paralysis is still further simulated.

In the later stages of such cases a *skiagram* is calculated to give valuable information as to the altered form of the upper end of the humerus, which it is not able to furnish in the newly born, owing to the cartilaginous condition of the end of the bone.

In the *treatment* of genuine cases of obstetric paralysis the early use of electricity must still be looked upon as the dominating remedy. But a more radical

procedure has been recommended from many quarters.

Kennedy has recommended that, if no indication of recovery from the paralysis shows itself in two months, operation should be performed on the brachial plexus. Kennedy (see also Spitzy) considers the Duchenne-Erb type of obstetric palsy to be due to a lesion of that part of the plexus where the fifth and sixth cervical nerves first unite, the damage being caused by tearing or pressure during difficult delivery. The nerves being torn, paralyses result, and at the site of injury a cicatrix is formed or the nerves come to be included in cicatricial tissue. The nerves must then be wholly freed from the scar tissue (*neurolysis*), or this must be dissected out *in toto* as far as is necessary, so that the cut ends of the nerves present a normal appearance. By suitably flexing the head and neck, Kennedy was able to suture the two proximal nerve trunks to their distal three branches, and attained thus good results in five consecutive cases. Similar procedures are reported on by W. Harris and Warren Low, and by Tubby.

Indications for early operation are given by Bardenheuer. In the case of obstetric paralysis and, indeed, of all forms of pressure paralysis, as, for instance, that following on dislocations or bruising, Bardenheuer considers that exposure of the nerves is indicated in view of the tediousness and uncertainty of a spontaneous recovery, provided that a reaction of degeneration is demonstrated within a fortnight. There is then frequently found severe damage to nerves, as in one case, for example, rupture of the fifth and sixth nerves and intra- and extra-neural hæmorrhage of the seventh and

eighth, which was rapidly recovered from after *neurotomy*. This term Bardenheuer applies to the linear division of the nerve-sheath, which renders possible the free escape from within the sheath of the tissue fluid poured out consequent on the injury, and thus apparently removes the harmful pressure on the nerve-fibres. Codivilla goes a step further in the exposure of the affected nerve trunk. According to him, in those cases of high paralysis of the brachial plexus in which one suspects tension on, or contusion of the nerve root, one should attempt the removal of the transverse process [over which the nerve runs in a groove], so as to favour the recovery from the neuritic conditions.

Whatever views one may hold as to early operation in obstetric paralysis, one is confronted with the difficulty of exact diagnosis. Electrical examination can settle the diagnosis of serious nerve lesion, but it is hardly practicable at this period, for, as Oppenheim points out, it is scarcely possible in the first five or eight weeks to determine disturbances of electrical excitability [3a].

Accordingly, we are not in a position straightway to dispense either with *electrical treatment* of proved value, or later on with *exercises* suitable for the affected muscles.

Heusner has devised a corrective apparatus to support

[3a] The amount of surface fat present may cause difficulty, but C. and A. Westphal have shown that in new-born infants the peripheral nerves and the muscles are incompletely developed, with the result that they react only to strong currents and with delayed contraction. Mann states that it is not till after five to eight weeks that the normal conditions are established.—Translator.

the arm and to improve the exaggerated internal rotation. It consists of a steel wire spiral of twenty to thirty turns surrounding the arm, attached at the shoulders to the axillary support of a corset, and at the other end to a leather mitten on the hand.

If one has to deal with a case of longer standing, in which the condition of the paralysed or weakened muscles is stationary, one will incline more readily to operative procedures, provided that the circumstances hold out a prospect of success, for even the best apparatus is found to be burdensome after a time. Even if it is not possible to bring about a complete restitution to the normal, it may yet suffice, perhaps, to restore the power of movement in the direction in which its want is most felt. With this object Hoffa, among others, has performed plastic operations on the muscles. He separated a part of the trapezius and stitched it to the paralysed deltoid, attaining thereby an unquestionable improvement in the usefulness of the arm. Some surgeons have also employed the pectoral muscles as substitutes for the deltoid.

A much more promising procedure for the future would seem to be the so-called *nerve anastomosis*.

Spitzy thus treated a boy, aged 12, who at birth had sustained a fracture of the head of the humerus and of the glenoid and also suffered from obstetric palsy. The condition was as follows: abduction and elevation of the arm very limited in extent; complete voluntary extension of the arm impossible; supination of the forearm, extension of the hand and of the fingers impossible.

As the signs pointed most prominently to paralysis of the musculo-spiral nerve, a partial central implanta-

tion [4] of the median into the musculo-spiral was carried out, which gave an excellent result. The patient eventually was able to play the piano with the affected hand, and, using it alone, to steer his bicycle. In a similar case, Lange obtained a satisfactory result simply by a shortening of the tendons of the over-stretched, paretic extensor muscles.

In another case of Spitzy the only notable sign was a marked internal rotation of the arm. On exposing the upper portion of the brachial plexus (Erb's point) it was found that the fine suprascapular nerve had been completely destroyed by the injury at birth and subsequently involved in the cicatricial formation. Its restoration by anastomosis was impossible here. Spitzy relieved the internal rotation by proceeding directly to an *osteotomy* of the humerus close to the insertion of the deltoid. The distal portion was then rotated about

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[4] Scheme of the methods of transplantation of nerves according to Spitzy :—

(1) Implantation (grafting).—Performed repeatedly for facial paralysis.

A.—Peripheral Implantation.

(*a*) Peripheral complete Implantation.—The whole of the peripheral stump is attached to a neighbouring nerve trunk.

(*b*) Peripheral partial Implantation.—Only a portion of the peripheral end of a paralysed nerve is attached to the adjacent intact nerve.

B.—Central Implantation.

(*c*) Central complete Implantation.—The whole proximal stump of a functionating motor nerve is grafted to the trunk of the paralysed nerve.

(*d*) Central partial Implantation.—A strip of a functionating motor nerve is connected to the paralysed nerve so as to convey central impulses to it.

(2) Cross Connections.—The whole proximal stump of one nerve is joined to the peripheral stump of another nerve.

(3) Anastomoses of other complex types.

90°, so that the forearm in the horizontal position faced upward. The usefulness of the arm was greatly improved by this alteration, as the child was then able to bring its hand to its head or mouth, which previously it could not do.

Vulpius also adopts transverse osteotomy of the humerus at the level of the deltoid insertion, both in cases of genuine obstetric paralysis as well as of the pseudoparesis due to separation of the upper epiphysis. The limb is then bandaged with the humerus in a position of marked outward rotation and abducted to a right angle. A good result is obtained in both the conditions since, owing to the faulty position of the transverse axis of the elbow, when the humerus is internally rotated, whatever the cause may be, the arm cannot be raised above the horizontal nor can the hand touch the face.

In addition to the traumatic paralyses affecting the brachial plexus, it is liable occasionally to paretic conditions associated with the presence of *cervical ribs*.

The symptoms of this condition manifest themselves first by irritation of nerves. The patients suffer first of all from pain and disturbances of sensation in the arm and shoulder. Objectively one finds alteration of sensibility in the course of the seventh cervical and first dorsal nerves, especially of the latter (W. Hinds Howell) [5]. The sensibility to touch is less affected

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[5] An interesting and unique case is recorded by G. Bertram Hunt (*British Medical Journal*, 1909, vol. ii, p. 314), in which severe clonic spasm of the diaphragm was associated with a large palpable cervical rib on the left side. The spasm was attributed to irritative pressure by the rib on the phrenic nerve and was completely relieved after excision of the rib.—Translator.

than that to pain, and diminished or abolished sensibility may be evidenced. The muscles of the upper arm are more paretic than those of the hand; at the same time one finds an atrophy of the muscles of the hand, which shows itself chiefly in the thenar eminence, to a less degree in the hypothenar and the interosseus muscles. When cervical ribs are present on both sides, but the symptoms appear only on one side, a trauma affecting only this side may be the explanation, but Hinds Howell considers that variation in the direction of growth of the rib may determine the occurrence of symptoms. He holds that if the rib is directed horizontally or posteriorly no special disturbance will result, whereas a rib which points forward, or downward and forward, may exert pressure on the brachial plexus.

Cervical ribs sometimes are free at their extremities, but sometimes are attached to the first rib loosely or by bone (Ranzi). The costal processes [anterior roots of the transverse processes of the cervical vertebræ] must not be mistaken for cervical ribs. In children under 10 years these portions frequently are not yet united to the remainder and are specially prominent (Krause).

A characteristic feature found in cases of cervical ribs is the presence of a very unyielding cervico-dorsal skoliosis, situated high up and presenting but a short curvature. The asymmetry of the contour of the neck is striking; the neck-to-shoulder line on the side of the convexity is placed much higher (fig. 14), and the neck consequently appears short and thickset. The scapula on the side of the convex curvature is displaced up and out. There is a slight compensatory curve of

the lower dorsal spine and there is often, too, a skoliotic asymmetry of the face (Krause). One can detect very commonly a hard, bony prominence in the supraclavicular fossa. Finally, the employment of skiagraphy will supply definite information to settle the diagnosis.

FIG. 14.

If electrical treatment is incapable of putting matters right, it is necessary to remove by operation the cervical rib which is the cause of the neuritis or paralysis, in which event care must be taken to ensure the complete removal of the periosteum of the bone, a matter of some difficulty. Weber, and likewise Tilman, has observed improvement in regard to the paralytic manifestations

(affecting the lower region of the plexus) within but a few days after extirpation of cervical ribs, and other observers have reported favourably on the relief to affections of the nerves following the excision of a cervical rib.

Paralysis of the **serratus magnus** muscle is a condition that presents a characteristic appearance, which is readily comprehended if we consider the function of the serratus, namely, to steady the shoulder-blade on the thorax and to rotate it round a sagittal axis, the inferior angle being directed outward. According to Mollier's view the muscle must be looked upon as consisting of two portions, an upper and a lower, corresponding to its mechanical action. The uppermost fibres fix the scapula firmly to the thorax, so that its internal border is parallel to the spine; the rest of the muscle serves to rotate the inferior angle of the scapula outward. For the arm to be fully elevated, it is necessary for the scapula, with the assistance of the trapezius muscle, to be rotated till the glenoid cavity, from its almost vertical position when at rest, comes to be nearly horizontal. Should this movement of the scapula be absent in paralysis of the serratus, the arm can hardly be raised above the horizontal level. If the arm is raised in the lateral direction, one observes the inner border of the scapula project backward and toward the middle line; if in the forward direction, then one sees the familiar wing-like projection of the shoulder-blade. At the same time it is possible that the arm may be fully elevated, even though the serratus is paralysed, provided that the middle portion of the trapezius is strong enough to compensate and rotate the scapula outward.

To assist, if desired, the customary therapeutic measures by mechanical means, one may attempt to fix the shoulder-blades to the thorax by an inclusive bandage and thus partly correct their tendency to project. For this purpose one may employ the special braces for the correction of round shoulders, recommended by Bouvier (fig. 15), and by Glasberger (fig. 16), or other similar patterns. But even the best band-

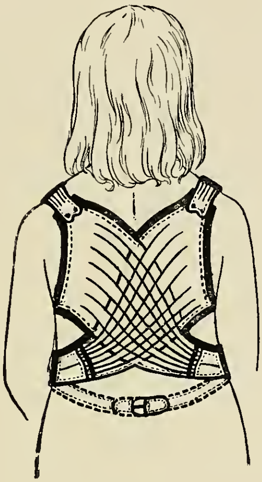

FIG. 15.

age of this kind can only partly serve its purpose, because it would be necessary to pass it circularly round the chest in order to press the shoulder-blades quite firmly against the thorax, a procedure which would hinder proper respiration. An orthopædic corset suitably modelled to the trunk might be found best in the end.

In order to get rid of the projection of the scapulæ by operative means, Von Eiselsberg has tried suturing

the two bones to one another. Even should success attend this operation, which Von Eiselsberg performed in the case of a paralytic condition of the shoulder-girdle due to progressive muscular atrophy, it will fail, just as does treatment by apparatus, in replacing the second important function of the serratus, that is, the rotation of the scapula round the sagittal axis.

Attempts have therefore been made in incurable

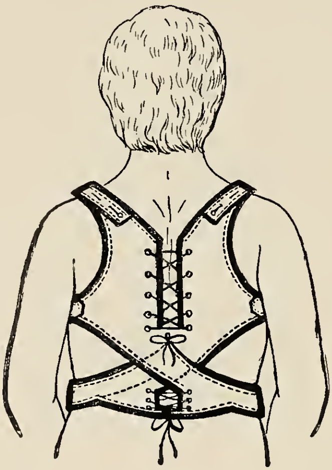

FIG. 16.

cases of serratus paralysis to substitute some other muscle for it by a plastic operation. In a case of this kind in which the uppermost fibres of the serratus were still functionating. Samter transplanted part of the pectoralis major, attaching it to the scapula. The muscle was divided lengthways, injury to its nerve supply being avoided, and the lower part of the muscle, opposite the axillary cavity, was detached along with its tendinous insertion from the humerus and was then stitched to the inferior angle of the scapula. The arm

was kept elevated during the process of healing, so that later on the transplanted muscle should have a good purchase. The patient was able subsequently to raise his arm to the vertical position. Katzenstein was equally successful in treating a complete paralysis of the serratus by transplanting the insertion of the pectoralis major from the humerus to the inner border of the scapula, and also transplanting the origin of a portion of the trapezius and rhomboid muscles. A satisfactory functional result was also obtained by Enderlen, who separated the sternal from the clavicular portion of the pectoralis major, as far as preservation of the nerve supply permitted, and then sutured the detached insertion of the sternal portion to the inferior angle of the scapula. The arm was bandaged up in an elevated position. The patient was capable of lifting his arm almost to the vertical, while the previously existing wing-like projection of the shoulder-blade was hardly noticeable.

Mention should be made at this point also of **paralysis** of the **trapezius** muscle, which, though innervated by the cervical plexus and the spinal accessory, may stand in close relation to the serratus magnus muscle in regard to its functional action. It has already been stated that this muscle assists the serratus in raising the arm by rotating the scapula outward around the sagittal axis, in that it fixes the acromion. When the middle portion of the trapezius is paralysed, apart from this loss of function just described, the appearance presented by the shoulder is characteristic (Duchenne). The shoulder sinks forward and outward; the inferior angle of the scapula comes nearer to the middle line of the back, and the acromion

sinks down and out, standing at a lower level than the superior internal angle, which is supported by the levator anguli scapulæ; at the same time the clavicle projects forward (Mollier). The endeavour to raise the arm laterally or anteriorly necessitates an excessive action of the rhomboids, as substitutes for the trapezius, with the result that a lateral curvature of the spine may develop.

In those rare cases in which the cause of the paralysis is attributable to *caries of the uppermost cervical vertebræ,* with the formation of tuberculous granulation tissue or abscesses, the treatment of the paralysis is then, of course, the treatment of the spondylitis high up, and is carried out on the same principles that we shall describe later on in dealing with compression myelitis due to caries.

The customary electrical treatment of peripheral paralysis of the trapezius may be assisted by the use of a figure-of-eight bandage round the shoulders, similar to that of Petit or that of Bouvier above mentioned. By such means one can brace back the sunken shoulders and thus lessen the strain on the deltoid and serratus muscles when the arms are raised.

Katzenstein relieved one case of permanent paralysis of the trapezius by substituting for the three portions of the affected muscle flaps taken from the sound trapezius of the other side, employing also the latissimus dorsi. The lowermost portion, which serves to draw the shoulder-blade toward the middle line, was replaced by a strip, running in the appropriate direction, taken from the latissimus dorsi, while the middle and uppermost portions were replaced by corresponding flaps taken from the healthy trapezius.

Paralysis of the **circumflex nerve** involves in all cases loss of power in the **deltoid** muscle, but not necessarily inability to lift the arm. In regard to this the observations of Duchenne, Oppenheim, E. Loewe, Rothmann, and others have shown that, even with complete paralysis of the deltoid, the arm may be raised by the supraspinatus, which becomes hypertrophied. An additional part in the action is taken by the serratus magnus, pectoralis major, trapezius, infraspinatus, and the muscles of the upper arm. During the course of a temporary but prolonged paralysis of the deltoid, the unrelieved weight of the arm may give rise to a *subluxation* of the head of the humerus, in consequence of which the deltoid is over-stretched and functional weakness remains, even after recovery. It is therefore desirable, during the course of treatment, to have the arm supported in a sling.

Transplantation of the pectoralis major was the method adopted first by O. Hildebrand in a case of flail-joint at the shoulder, due to deltoid paralysis, and with a very good result. Care being taken to avoid injury to the nerves and blood-vessels of the muscle operated on, the muscular origin of the pectoralis from the ribs is separated and displaced backward over the deltoid so that the direction of the fibres corresponds. A similar plan was followed by Samter in a bad case of paralysis of the deltoid, associated with a fracture of the greater tuberosity of the humerus. Electrical and mechanical treatment extending over eight months had been without result. Samter transplanted the upper half of the pectoralis major on to the anterior and upper aspects of the joint; the posterior aspect was not included for fear of damage to the nerves and

vessels. Eighteen days after the operation the muscle was electrically excitable and functionating, being capable of raising the arm some 40 to 50°, while the serratus magnus completed the movement of elevation.

More recently Vulpius has tried innervation of the circumflex nerve in deltoid paralysis due to poliomyelitis. In one case, peripheral complete implantation of the circumflex on to the ulnar nerve gave a bad result, but in three cases, in which central partial implantation from the median or the musculo-spiral nerve on to the circumflex was performed, the outcome was satisfactory as indicated both by the functional usefulness and by the electrical reactions. The latter test of true success was negative in an attempt made by Gersuny to transfer the functional activity of the spinal accessory to the circumflex, by means of partially uniting the normally innervated trapezius to the paralysed deltoid, with the idea that the region of innervation of the spinal accessory might extend to that supplied by the circumflex.

An isolated **paralysis** of the **suprascapular nerve,** which supplies the **supra-** and **infraspinatus** muscles, is evidenced by interference with the external rotation of the arm. Means of benefiting this disability have been referred to in connection with obstetric palsy.

As regards peripheral paralysis of the main nerve trunks of the arm, the *musculo-spiral,* the *median,* and the *ulnar,* **paralysis** of the **ulnar nerve** gives a specially characteristic result in the familiar claw-like deformity of the hand (*main en griffe*). The inability of the interossei and the lumbricales to flex the proximal phalanges and to extend the distal ones, permits of a dominant action of the extensor communis digitorum

and the long flexors of the fingers. The consequence is a marked extension of the proximal phalanges and a flexed or claw-like position of the middle and terminal phalanges, especially noticeable on the ring and little fingers, less so on the index and middle fingers, as the lumbrical muscles acting on their terminal phalanges are innervated by the median nerve and thus still help to extend them.

In **musculo-spiral paralysis,** owing to the loss of power in the extensors, the hand is dropped, assuming a position of maximum flexion (ulnar flexion), as do also the fingers at the metacarpo-phalangeal joints.

Paralysis of the **median nerve** produces the least striking effect on the posture of the hand. One may often notice ulnar flexion and supination on account of the predominant action of the flexor carpi ulnaris and the supinator muscles.

In determining the proper *treatment* of peripheral paralysis of nerves, it is important to know whether one has to deal with an actual solution of continuity of the nerve or not. Neuritic paralysis, arising from pressure or contusion, is amenable to the usual conservative treatment. The application of electricity first and foremost, then massage, hydrotherapy, and other physical methods of treatment and internal medication are capable of restoring the damaged nerve conductivity. The treatment is aided with advantage by the use of mechanical appliances, especially those making use of weights. By applying a weight and letting it swing in the direction of the sphere of action of the paralysed muscles, one is able, for the time being at least, to oppose a resistance to the action of the antagonizing muscles.

With treatment on these lines the paralysis of the musculo-spiral nerve may pass off even in those numerous cases due to callus formation after fracture of the humerus. If benefit does not follow, operative measures must be adopted and the nerve freed from the surrounding callus, just as from compressive cicatricial tissue (*neurolysis*). Strong bony callus should be removed. In order to preserve the isolation of the nerve, it is either embedded in the surrounding soft parts or else artificially isolated, as, for instance, by sheathing it in a portion of prepared calf's artery, as suggested by Foramitti.

If, however, the physical continuity of a paralysed nerve is broken, operative treatment by *nerve suture* is the surest method of restoring function. This operation is justified, not only for the immediate or primary suture of divided nerves, but also for secondary suture, since it may meet with success even after years of loss of function.

The cicatricial tissue which fills up the gap at the interruption of continuity of the nerve has to be excised, and the stumps of the nerve have then to be united. If a considerable distance separates the ends of the nerve a simple reunion of them is impossible, unless one adopts the heroic method of approximating them by means of resection of a suitable length of bone (Trendelenburg).

The restoration of conductivity may, however, be attempted by other means. Either a neighbouring healthy nerve trunk is employed for the neurotization of the peripheral stump of the nerve, *i.e.*, implantation or nerve grafting (Létiévant, Spitzy), or else, in lack of some such suitable nerve trunk, the gap in the

damaged nerve is bridged over by nerve tissue from some other source. The transplantation of animal nerve has been recommended by Gluck for this purpose, while Létiévant has proposed the use of nerve flaps, formed by splitting the ends of the divided nerve longitudinally, a method which has proved successful.

If the restoration of nerve function is found impracticable, there only then remains to try to restore the balance of muscular action by means of a *transplantation of tendons* [6]. We may take for an example the case of a forearm affected by complete musculo-spiral paralysis, in which the following procedure might be adopted (Hoffa):—

The tendon of the extensor carpi radialis longior is shortened; perhaps also those of the extensor carpi ulnaris and the extensor longus pollicis. In addition, an active transplantation of the flexor carpi ulnaris on to the extensor communis digitorum and an active transplantation of the flexor carpi radialis on to the extensor longus pollicis are carried out.

This makes extension of the fingers possible and by the shortening of the extensor tendons serves to bring the wrist into a position of medium dorsiflexion. Shortening of the extensors alone has been tried also with success in simple paresis of the muscles supplied by the musculo-spiral, and by restoring the tone to the over-stretched extensors has enabled them to perform their duty satisfactorily (Pürckhauer).

However well the transplanting of tendons may succeed, the method has the inherent disadvantage that

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[6] Hoffa proposes the use of the terms active transplantation, when the tendon of a healthy muscle is transferred to a paralysed one, and passive transplantation when a non-functionating, passive tendon is attached to a functionating one.

it involves the giving up as lost of the whole musculature innervated by the damaged nerve, and the substitution for it of healthy individual muscles. It thus amounts to perpetuating an existing loss on the one hand, and on the other to occasioning a further loss by the borrowing of active, useful muscles. In the upper extremity particularly any diminution of muscular power is doubly to be regretted.

The restoration of nerve impulses to the paralysed muscles, when that is made possible by connecting them up again to the motor centres by means of a successful nerve grafting, renders a service of very much greater value than does even the best transplantation of tendons. Certainly one cannot regard nerve grafting as a method already fully worked out, since many important problems still await solution in this connection, as, for instance, the determination of the topographical arrangement of the individual motor tracts in the main nerve trunk, a question which Stoffel, a pupil of Vulpius, has been the first to bring into prominence [7].

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[7] Stoffel has been engaged in an extensive research on the internal anatomy of the peripheral nerves. Contrary to the previously held belief that the nerve fibres are distributed at haphazard throughout the nerve-trunk, he has found that the nerve twig to any individual muscle preserves its unity and independence after joining the main trunk. It has thus been possible to determine for each main nerve the normal anatomical arrangement of the bundles of fibres passing to a particular muscle or group of muscles. This topography is fairly definite and constant, and therefore admits of the recognition and isolation of any individual nerve-bundle desired at an operation, without even the necessity of tracing it from the muscle upward. Its identity, when isolated, may also, of course, be tested by applying a galvanic current of such minimal strength as not to excite adjacent motor twigs. (For the description of his discoveries, see "Orthopädische Operationslehre," Part II., published by F. Enke, Stuttgart.)

Stoffel first made practical application of this topographical

But the increasing number of operative successes such as Spitzy has been able to record in the course of years, justifies the preference being given to this method; which on theoretical grounds also stands first.

The general determining factor in the choice of the method of nerve grafting is the distribution and localization of the paralysis, as Spitzy points out. In central complete implantation the nerve to be substituted is wholly disconnected from its terminals, in central partial implantation it is weakened in respect of the strip separated from it. In peripheral implantation a similar state of affairs exists, but affects, not the functional, but the paralysed nerve. Since the main nerve trunks in the arm are *mixed* nerves, one must accordingly consider a partial implantation first of all, especially when only motor paralysis is present. If a nerve trunk is completely divided, then complete peripheral implantation is the method of choice. A central

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method by isolating and excising from a nerve trunk the particular nerve twigs which innervated spastically contracted muscles. The further natural development from this was to perfect operations of nerve-grafting, so that healthy nerve-tracts supplying muscles of minor importance might alone be separated from their trunk and be implanted in the paralysed nerve. As regards the latter, as Stoffel points out, the topographical knowledge is of great importance, as otherwise the *motor* twig may be implanted into the *sensory* fibres of the second nerve trunk, since these form a considerable part of the whole.

Since Stoffel's method was published it has been tried, and with success, mostly for the relief of muscular spasm in spastic conditions. The complete division of motor nerves (obturator) for this object had been performed by Lorenz some twenty years previously, but not further developed, for, as he emphasizes, spastic muscles become trophically shrunken and so the relief of the spasm does not ensure recovery from the existing contracture, which is largely the source of the patient's disability. (See *Verhandlungen der Deutschen Gesellschaft für orthopädische Chirurgie*, 1912, p. 51.)—Translator.

partial implantation from an adjacent nerve is recommended by Spitzy, when the predominant action of that nerve is the cause of the deformity, as for example in that case of obstetric paralysis (see above), in which he performed with a most favourable result a central partial implantation from the median on to the musculo-spiral. Leedham Green reports a peripheral complete implantation of the injured median nerve into the ulnar with restoration of function after six months, and Horsley reports a similar case. Henle treated two cases of ulnar paralysis with claw-hand (after injuries in war) by complete peripheral implantation of the ulnar into the median. After some four to six weeks he observed the first movements in the paralysed muscles of the hand and an improvement in the claw-like deformity.

Treatment by *apparatus* in cases of paralysis of the main nerve trunks of the arm has been relegated to the background by the modern advances in operative treatment, for it is an insoluble proposition to replace such a delicate mechanism as is concerned in the play of the musculature of the upper extremity by means of any apparatus with its artificially produced movements.

Should it be a matter of necessity to make use of some appliance in paralysis, for musculo-spiral affections Heusner's apparatus, which is similar to, but simpler than, that of Collin-Mathieu, is to be recommended. Heusner's bandage (fig. 17) consists of a leather sheath fitted to the hand and forearm, and provided with adjustable straps, passing under a loop on the back of the hand, continuous with rubber bands which are attached to the parts encircling the proximal phalanges of all the fingers and the thumb. By this means the wrist is maintained in a position of medium dorsiflexion

and the hand is rendered somewhat more useful by the movable bands leading to the fingers.

Peripheral **paralysis** of the **anterior crural nerve,** associated with loss of power in the **quadriceps extensor** muscle and also of the ilio-psoas [iliacus portion] offers relatively seldom to the orthopædic surgeon an opportunity for interference. In many cases paralysis in the region supplied by the anterior crural, appearing first on one side and then on the other, points to the existence of spondylitis affecting the lumbar vertebræ or, it may be, the development of an abscess as the cause of the condition, in which case attention is to be directed

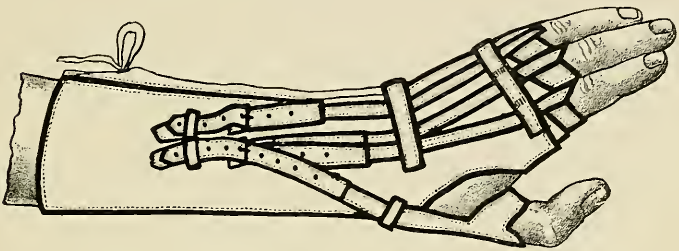

FIG. 17.

to all the measures called for in dealing with a spondylitis accompanied by indications of compression of the spinal cord.

If, in the course of conservative treatment of a peripheral paralysis of the anterior crural, the knee shows a tendency to contracture in the flexed position, one may oppose this by applying a moulded splint provided with rubber bands so arranged as to extend the knee.

As regards operative interference in quadriceps paralysis, which hardly ever comes into consideration in dealing with the peripheral type of paralysis, this is

discussed later on in connection with acute anterior poliomyelitis, as is also paralysis of the sciatic nerve.

In reference to the manœuvres for the reduction of congenital dislocation of the hip, Lorenz has called attention to the possibility of **paralysis** from rupture of the **sciatic nerve,** in which event its *external popliteal* (peroneal) division and the muscles supplied by this are specially affected. From the first, Lorenz had surmised that the external popliteal nerve was particularly liable to laceration on account of its firm attachment by connective tissue to the head of the fibula at its passage between the heads of origin of the peroneus longus muscle. As a matter of fact it has been demonstrated by the searching investigations of Von Aberle, that the binding down of the external popliteal nerve by rigid connective tissue in the region of the lowermost portion of the biceps tendon, the head of the fibula, and at the point where the nerve pierces the sheath of the peroneus longus, may be prejudicial to it, should the nerve be subjected to undue tension. Moreover, there is the fact that the nerve is further tied down by its branches and that its anterior tibial division, which is chiefly a motor nerve, is principally affected by the fixation. In this way, therefore, apart from the greater vulnerability of motor nerves, may be explained the fact that, in spite of motor paralysis, sensibility is often intact.

This observation does not find an explanation in the theory of Hofmann, who assumes as the cause the poor distribution of blood-vessels to the external as compared with the internal popliteal nerve. Hartung considers that the greater liability to laceration shown by the external popliteal nerve is due to its being a thinner nerve than the internal popliteal, and also because its

fibres pass over three bony prominences or fulcra, in contrast to only one in the case of the internal popliteal. The external popliteal rests in its course on (1) the ilio-pectineal line, (2) the neck of the femur, (3) the base of the head of the fibula; whereas the internal popliteal, with the exception of a portion of its fibres which crosses the ilio-pectineal line, rests only on the neck of the femur. It should be further added that the relatively superficial situation of the external popliteal nerve must be taken similarly into consideration in the operative treatment of contractures of the knee-joint, if the risk of paralysis of this nerve is to be avoided.

Deformities of the foot are liable to develop in consequence of peripheral **paralysis** of the **external** and **internal popliteal nerves,** and such must be guarded against during the course of treatment. When the *external popliteal* is affected the tendency which has to be encountered is to the production of a *talipes equinus* or a *talipes equino-varus*. With the patient recumbent the foot drops by its own weight and remains dependent, because of the absence of power in the flexors of the foot. Gradual contracture of the gastrocnemius and soleus ensues, and thus the deformity develops from the faulty position. In order to prevent this, the patient, if confined to bed, must have a suitable appliance fitted to the foot, which may be either a simple plaster-of-Paris mould or one made up by a professional bandage-maker from a model. A plaster splint adapted to the sole of the foot and back of the leg, the foot being set properly at a right-angle, and bandaged in place, will suffice to support the limb in correct position, but an apparatus fitted with rubber bands to flex the foot, as shown in fig. 27, may prove more efficient. In either

case the limb is open to inspection and the carrying out of treatment at any time.

If the case is seen only in the later stages when the foot has become pointed or a club-foot has resulted, it is essential to correct the deformity so that the patient may be able to walk. This is carried out by means of Lorenz's method of modelling redressment [8], combined probably with tenotomy of the tendo Achillis, to overcome the pointing of the foot due to the contraction of the gastrocnemius and soleus. The foot is then fixed for several months in the improved position by means of plaster bandages. When the plaster is removed it can then be decided according to the result obtained whether the further wearing of an apparatus is necessary, or if a transplantation of nerves or tendons is desirable. The more detailed consideration of the indications for such measures in deformities of the foot

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[8] The term "modelling redressment," introduced by Lorenz, applies to a method of operation frequently referred to here in connection with various conditions of deformity. It is carried out with the patient fully anæsthetized and consists in a correction of the deformity carried out by means of manipulation, and sometimes, if advantageous or necessary, with the assistance of an adjustable apparatus. Lorenz has devised a special "redresseur" for the purpose. The method implies the slow, gradual and continuous application of force to reduce the deformity, but in such a way that the amount and the direction of its action is fully under control, in these respects differing from the French method of forcible correction (*redressement forcé*) which consists in the application of manual power in a single act which cannot be regulated or accurately localized and estimated.

The operation is eminently suited for deformities of the soft parts, as in the case of contractures, but the soft bones of children are also largely amenable to modelling in this fashion, as in the case of club-foot. Its effect, however, is more especially "a modelling by slow stretching of the plastic soft parts, particularly the ligaments, whereby the bones are brought into their mutually correct position."—Translator.

due to poliomyelitis, to be described later, applies equally to the foregoing, as well as to those deformities acquired as a consequence of peripheral paralysis of the internal popliteal nerve.

Orthopædic treatment of the foot is specially called for in cases of paralysis of the *internal popliteal* to prevent the production of a *talipes calcaneus* or *calcaneo-valgus*. These conditions may develop with particular ease since, with but a slight weakening of the supinator muscles, the strain placed on the foot by the weight of the body suffices to cause an exaggerated position of pronation (flat foot).

Neuralgic Affections.

The frequency with which a practitioner diagnoses *neuralgia* or neuralgic pains as an independent disease may be said to diminish proportionally with the growth of his experience. One may quote the views of Oppenheim as worthy of consideration :—

" A diagnosis of neuralgia should not be made until careful examination has excluded any organic disease which may give rise to the pain owing to some gross changes in the nerve or, it may be, in the central organs. Inflammatory conditions and new formations in the neighbourhood of the nerve roots are specially prone to present themselves for a long time in the guise of simple neuralgia."

Thus affections of the uppermost cervical vertebræ, such as the chronic rheumatic or deformative inflammatory conditions, but especially tuberculous disease, may be mistaken for a simple occipital neuralgia. In like fashion *spondylitis* occurring in the cervical, dorsal, or lumbar regions may set up radiating pains which

simulate brachial neuralgia, intercostal neuralgia, lumbar neuralgia, and sciatica. The condition there present is less that of a genuine neuralgia than of a neuritis, which has arisen in the region of the corresponding nerve roots from extension of the inflammatory process to them or from pressure on them. When there is pain of this kind present therefore it is necessary to keep *spondylitis* in mind in making a differential diagnosis. Certainly it is not likely that a typical case with an evident hump, with abscess formation, or with symptoms of implication of the spinal cord will be overlooked or not recognized; but there are, however, cases, particularly in the earliest stages of the disease, which may allow of a mistaken diagnosis. In the case of adults a long time may elapse before any gibbosity forms, and the period necessary may be all the longer when the disease attacks a region of the spine which presents normally a lordotic type of curve. It may so happen, then, that a small hump may already exist in the lumbar region and yet not be evident, since the effect of a gibbous formation at this level is first to flatten out the spine, and only at a later date to render it kyphotic, when the gibbosity will appear as a distinct projection.

In children, as a rule, the hump develops more rapidly; nevertheless, it may be a matter of some months, and it would be a serious error of omission on the part of the practitioner, and a grave injury to the child, if for lack of correct diagnosis, valuable time should be lost in symptomatic treatment by anodyne remedies of the pains in the chest or abdomen of which the child complains. There is here but one radical method of treatment, and that is *fixation* of the spinal

column, and, if necessary, relief of the tender vertebræ from pressure. The general attitude itself of the child indicates, indeed, the necessity of this line of treatment, and at the same time furnishes diagnostic points for a timely recognition of the vertebral caries even before the hump is visible. A child so affected is painfully intent on preserving without variation some particular posture which he finds the most bearable, and he will not permit of any alteration of it. Children, who were previously lively and frolicsome, become quiet and disinclined to movement, as they become instinctively conscious that only thus can they maintain unaltered that position of the body which gives them least pain. The gait has something peculiarly stiff about it, for the child suppresses any swinging of the body when walking, owing to reflex contraction of the muscles of the spine. One sees not infrequently, and specially in cases with an asymmetrical disease of the vertebræ, that the spine is fixed with an inclination to one side (fig. 12) [8a]. If the patient is made to pick something up from the floor, he does so without bending the whole spinal column, but instead he flexes the hips and knees sufficiently till he can reach the floor with his hands, while still maintaining the fixed upright attitude of the spine. When rising he extends the hips and knee-joints, and in doing so supports himself with his hands on the thighs.

One can test the resistance offered by the spastic muscular fixation of the spine if one makes the attempt to bend it backward, either by pressing back the shoulders or by lifting the pelvis with the patient lying on his face. It is found to be impossible to lordose the

[8a] See p. 50.

spine by these means, as could be done at any time in normal circumstances. The same state of affairs is again in evidence if one tests for the lateral mobility of the pelvis on the spine that is always ordinarily present. In cases of spondylitis resistance is felt either on one or on both sides. Commencing contraction of the psoas can be demonstrated before an abscess is already distinctly palpable, if one lays the patient on his face and attempts to extend the thighs backward. In a normal individual this is readily done, and the effect shows itself in a lengthening of the gluteal fold, but in early contraction of the psoas the hyperextension of the hip-joint is not possible.

Neuralgic conditions in the regions of the cervical or the brachial plexus occur in occasional association with *cervical ribs,* but an interdependence of these two conditions is to be viewed with reserve, since Oppenheim, Marburg, and others have recorded the coincident occurrence of cervical rib and *spinal gliosis* [*syringomyelia*]. Franck has reported on a patient who suffered from severe pain in the left arm and paræsthesiæ following a crush of the shoulder. The existence of a cervical rib was demonstrated, which previously had caused no discomfort, but had now set up a neuritis.

Severe neuralgia in the region of the cervical and the brachial plexus was observed by Mickulicz (Kader) in a case of *congenital wry neck* on the side opposite the shortening. For the patient the endeavour to hold his head as erect as possible necessitated the active use of the antagonists to the shortened muscles, namely, the sterno-mastoid, the scaleni, and the trapezius of the opposite side. Mickulicz explained the origin of the

neuralgia and a commencing neuritis by the squeezing of the brachial plexus between the hypertrophied scaleni, and by the compression of cervical nerves by the muscles of the neck stretched against the curvature of the spinal column. The pains were relieved after correction of the wry neck by means of subcutaneous tenotomy of the sternal portion of the sterno-mastoid muscle.

Neuralgia is also familiar in connection with severe *skoliosis*. It may result from pressure on the nerve roots, but also from direct pressure on the nerves. One may thus find severe neuralgia occurring in the lower part of the abdomen, a lumbo-abdominal neuralgia, should the spine have sunk so far in consequence of a marked curvature that the last rib comes to rest upon the iliac bone, and thus causes compression of the intervening abdominal wall. Suspension of the body gives immediate relief, and this can be maintained by fitting a supporting corset, which takes off the pressure.

While neuralgic pain in both thighs is a symptom frequently associated with caries of the lumbar or of the sacral vertebræ, such pain on one side only may be an initial symptom of commencing *disease* of the *hip-joint*. The explanation of this is that the articular nerves to the hip-joint arise from the nerves of the lumbar plexus. The pain is felt less commonly on the front of the thigh in the region of the anterior crural than on the inner side of the thigh and in the knee, in the path of the obturator nerve. In children it is an almost constant early symptom of tuberculous coxitis that they complain of pain in the knee, and yet it is so frequently misconstrued that the supposedly affected knee is subjected to useless forms of treatment. In *arthritis deformans* also pain is met with referred to the region of the great

sciatic nerve. In such cases as those mentioned, examination of the hips will reveal the true state of affairs. The signs of disease of the synovial membrane here are to be found in the fixation of the thigh in a position of flexion, abduction and external rotation, and in limitation of movement in all directions. This spastic contraction of the muscles serves to differentiate it from the signs of an early stage of arthritis deformans of the hip, in which limitation of movement is only in the direction of abduction of the limb. The treatment of these forms of neuralgia is accordingly no other than the treatment of the causal trouble. In practice we find that the pains in the knee disappear in a patient suffering from coxitis as soon as one has fixed the hip by means of a well-fitting plaster-of-Paris bandage, thus protecting from disturbance the inflamed and hypersensitive synovial membrane. If necessary, in place of a plaster bandage one may apply provisionally a padded spica bandage round the hip.

Pain in the knee is frequently a symptom of disease of the *sacro-iliac articulation*, for the most part of tuberculous origin. In all these conditions of symptomatic "neuralgia" skiagraphy is able to furnish a valuable aid to diagnosis. Only after negative findings in X-ray examinations made in various directions should one permit a diagnosis of genuine neuralgia, which, as Von Frankl-Hochwart points out, may be only properly diagnosed by a process of exclusion.

Attention has been directed by Bernhardt to the connection between injuries to the foot ("sprains") and disturbances of sensibility, which may be distributed over the whole of the outer aspect of the thigh in the region of the external cutaneous nerve. This form of

neuralgia, which has been called "*meralgia paræsthetica*" [$\mu\eta\rho\acute{o}\varsigma$, the thigh] by K. W. Roth, has been observed by Pal in persons who have developed *flat foot*, particularly in elderly individuals at a time when they increased considerably in weight, or in patients with existing flat foot if they became stout. With a condition of meralgia on both sides, the degree of the flat foot was found to correspond to the severity of the meralgia, and if treatment of the flat foot were successful, the meralgia then passed off. Neuralgic pains in cases of flat foot may also occur referred to the gluteal muscles or the lumbo-sacral region, and then they are felt chiefly when the patient is standing and they largely or wholly disappear when he lies down (Pal). In the more severe cases, and but seldom, there may exist tenderness to pressure on the sciatic nerve or more commonly a diffuse tenderness along with a tired feeling felt in the gluteal muscles. An endeavour has been made by Ehrmann to explain the connection in certain cases between an existing condition of flat foot and the occurrence of pains in the pubic region and herpes progenitalis. Pains such as described are analogous to the neuralgias which remain after injuries, and may often be extremely persistent.

In contrast to the sciatica pains which are set up by flat foot are those cases of sciatica which are followed by the development of a spinal curvature. *Skoliosis* due to *sciatica* [neuropathic skoliosis, skoliotic sciatica] is a comparatively rare complication of the disease. Out of 100 cases of sciatica Stein observed only two with skoliosis, while in another computation of his, dealing with 800 cases, only five were found with this complication (0.62 per cent.).

This type of skoliosis is designated in accordance with the position which the trunk takes up in relation to the pelvis, since the deviation of the trunk determines the characteristic appearance of a patient suffering from the disease. One thus speaks of *homologous* deviation of the trunk, if the trunk—and with it, therefore, the dorsal spine—is inclined toward the limb *affected* by the sciatica, and of *heterologous* deviation of the trunk if it is found to be tilted toward the side *not affected*. At the same time it is to be kept in mind that the lumbar part of the spinal column presents a curvature opposite in direction to that of the dorsal region. As a rule the lateral curvature of the spine in the lumbar region is convex toward the affected side, in the dorsal region convex to the unaffected side. Curvatures in the opposite direction are much less frequent. Since the curvatures in the dorsal and lumbar portions of the spine are contrary to each other, and since the position of the trunk is the characteristic feature, it is better then to speak of homologous and heterologous deviation of the trunk than of reciprocal and crossed skoliosis, with which designation one must always state whether it refers to the dorsal or to the lumbar vertebræ.

The typical case of skoliosis due to sciatica is accordingly that with a heterologous deviation of the trunk, as shown in figs. 18 and 19. The trunk may be tilted to the unaffected side so markedly that the arm hangs free away from the body, while on the affected side the arm rests on the body. In addition to the lateral deviation there is also apparent a forward inclination of the spine. There exists then a *kyphosis* of the lumbar vertebræ as well as the skoliosis. The consequent vertical shortening of the abdomen shows itself

distinctly by the formation of several folds in the skin (fig. 19). On the affected side the limb is held abducted from the pelvis, and the anterior superior spine stands lower than that on the sound side, and the knee on the affected side is kept flexed.

When one makes an attempt to correct the posture

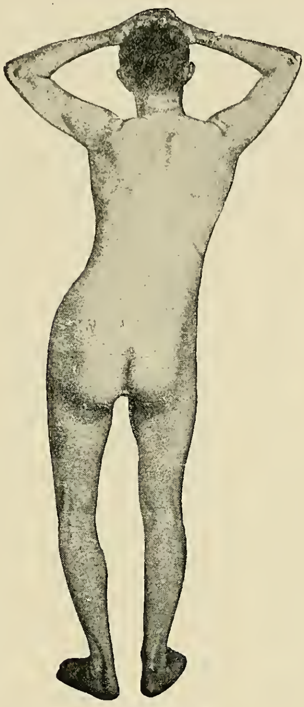

FIG. 18.

FIG. 19.

of the patient one is conscious of a strong resistance; the pathological attitude is, in fact, maintained by spastic contraction of the spinal musculature. The deformity, however, may allow of a further exaggeration. If the patient be suspended, the primary lumbar

skoliotic curve is not straightened out, should severe pain be present, and only the compensatory dorsal curve is eliminated. The apparent lengthening of the limb on the affected side, of which the patient himself is conscious, finds a natural explanation in this unyielding lumbar skoliosis, as in consequence of it the pelvis is depressed on the side of the convexity of the lumbar curve. The gluteal fold is placed lower on the affected side, while the anal fold lies obliquely, corresponding to the tilting of the pelvis. The fact that even when the patient is lying flat his limb seems permanently lengthened, though this is only illusory, is explained by the rigid, spastic state of the lumbar skoliosis.

The above-mentioned homologous deviation of the trunk is much rarer than the heterologous type. There is also a variable form of the skoliosis, in which the patient either voluntarily or involuntarily assumes alternately the homologous (reciprocal) or the heterologous (crossed) type of posture. This last-mentioned occurrence is to be classed among the greatest of rarities (Stein). The development of a skoliosis due to sciatica, which was first described by Albert and Nicoladoni, and later on more fully by Baginski, Schüdel, Gussenbauer, A. Lorenz, and others, is met with, as a rule, in those cases of sciatica in which not only the sciatic nerve and its branches are affected, but also other nerves of the lumbo-sacral plexus. Schüdel has demonstrated in all cases of the kind observed by him the presence of a point of greatest tenderness lying between the sacro-iliac synchondrosis and the posterior superior spine of the ilium. He ascribes this to implication of the nerve twig passing from the second

sacral nerve to the ilio-costalis muscle [sacro-lumbalis portion of erector spinæ]. In addition, however, the lumbar plexus usually appeared to be also affected. Stein has confirmed the existence of this typical tender spot in all cases of skoliosis due to sciatica.

Although we have now a very fair knowledge of the pathological anatomy of the parts affected, it cannot be said that the attempts to explain the condition of sciatic skoliosis are in any way consistent, and they largely fail to carry conviction in that they are usually applicable only to one single type of the skoliosis, either the heterologous or the homologous, but not to both varieties.

One group of the theories seeks a cause of the skoliotic posture in *paresis* or *paralysis* of the *spinal musculature* consequent on the lumbo-sacral plexus being affected, as a result of which the erector spinæ muscle on the affected side becomes incompetent, whereas that on the sound side becomes contracted. Schüdel considers that the muscles supplied by the diseased lumbar plexus take up a position of greatest relaxation. Gussenbauer holds that a laceration of the nerve and muscle fibres is the cause of a really traumatic inefficiency (" neuromuscular skoliosis "). According to Fischer-Schönwald the nerve branches from the lumbar plexus which pierce the muscle are diseased. Brissaud explains the skoliosis by *spasmodic contraction* of the muscles of the back on the affected side, Mann, on the other hand, by *paresis* of the erector spinæ of the affected side.

A second group of the explanatory theories depends on *mechanical factors* leading to the skoliosis. Thus

Albert assumed that the articular nerves were affected, on which account the weight was taken off the painful leg (which, as a matter of fact, is not at all sensitive in this respect). Nicoladoni supposed that the intervertebral spaces would be widened by a lateral curving of the spine and that pressure on the swollen nerves as they emerged would be lessened. According to Ehret, the affected limb is flexed at the hip and the knee and abducted, while the pelvis is depressed on the same side, so that tension may be taken off the nerves, and skoliosis is the consequence. Bähr also views it as being of static origin.

Among all the divergent views as to the cause of sciatic skoliosis one thing in common is recognizable, namely, that the peculiar posture is rigidly maintained by the patient in order to ease the affected side. The skoliosis is accordingly to be looked upon as a spastic, forced attitude. The patient adopts this attitude to relieve tension on the diseased nerve. An attempt to correct the posture by force elicits the severest pain in response. It is, then, the straining of the nerves of the lumbo-sacral plexus which causes pain, not the weight borne on the limb. The lumbar curvature combined with the flexion of the hip and knee relaxes the sciatic nerve, while the forward inclination of the trunk, the kyphotic tendency, that is always present, relaxes the lumbar nerves.

The *lumbar* skoliosis, which is rigid and spastic and irreducible in contrast with the mobile dorsal skoliosis, is accordingly to be judged as the *primary* curvature to which a dorsal curve is superadded as compensatory. Sciatic skoliosis is thus a reflexly spastic posture adopted perforce for mechanically easing the affected

nerves, to some extent therefore an *attitude of relaxation*.

The heterologous deviation of the trunk, in which type the lumbar vertebræ are convexly curved toward the affected side, best meets the requirements for obtaining relaxation, as may be seen by considering the accompanying diagram.

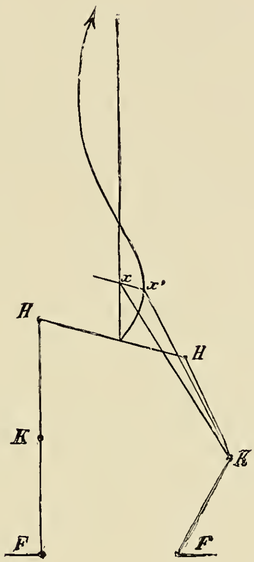

FIG. 20.

Looking at the diagram of the spine and limbs from behind (fig. 20) we can perceive that the diseased nerves x K (keee) are relaxed by the shortening of the distance as shown in the skoliotic position x' K, aided by the forward inclination of the spine and the flexion of the knee.

The relaxation occurs with less readiness in the much less frequent homologous skoliosis, which presents deviation of the trunk to the affected side, convexity of lumbar vertebræ toward the sound side (fig. 21). With the trunk held erect no relaxation of the nerves would follow, since x'' K is longer than x K. To bring about relaxation then, the spine as a

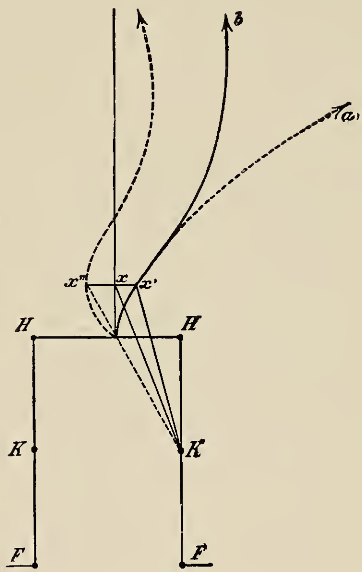

FIG. 21.

whole must be inclined toward the side of the disease. By this means, in a right-sided sciatica, the point x'' on the left convex lumbar curve is brought over to the position x'. x' K is shorter than x'' K and shorter than x K. The requirements for relaxation are thereby met. On account, however, of the trunk inclining

unduly to the right (x' a) the balance is disturbed, and this has to be restored by means of a compensatory right convex dorsal curvature of the spine (x' b). It is just on account of this disturbance of balance that, as a rule, in homologous deviation any flexion of the knee is avoided, as this would still further upset the balance because of the unavoidable sinking of the pelvis.

The *treatment* of *sciatic skoliosis* is one in common with the treatment of the sciatica itself, for, as a rule, the skoliosis disappears on recovery from the sciatica. In the acuter stages one may often give the patient ease by carefully applying a plaster-of-Paris bandage, which is adapted to the pathological posture, that is to say, with slight flexion of the knee and medium flexion of the hip, and which extends from the trunk to the ankle of the affected limb. Ehret, also, recommends fixing the leg with the knee flexed by means of a plaster bandage, reaching from the toes up to the thigh, and perhaps including the hips as well.

Cramer has successfully employed treatment with plaster bandages for several weeks, following that up by massage. In the after-treatment one also employs easy, active and passive gymnastic movements to improve the deformity, but not so long as they may still set up severe pain. In the acute stage one must leave untried any correction of the spastic skoliosis; in fact, rather encourage the lumbar skoliosis, by heightening the sole of the boot on the sound and apparently shortened leg.

For the *treatment* of *sciatica* itself, besides massage, mechanotherapy, hydrotherapy, and stretching of the nerve by open operation or without, the method of

injection has taken a prominent place in recent years. J. Lange recommended injections of a solution of:—

Beta-eucain	0.1 grm.
Sodium chloride	0.8 grm.
Aqua destillata	100.0 c.c.

Of this 70 to 100 c.c. are injected straight on to the nerves by means of a needle passed some 7 to 7½ cm. through the skin vertically down to the great sacrosciatic notch. Lange considers its action a mechanical one, the pressure of the fluid acting similarly to stretching of the nerve. Bum was able to demonstrate clearly on the dead body a mobilizing effect on the nerve sheath. To obtain this mechanical effect it is sufficient, according to Bum, if one injects 100 c.cm. of normal saline solution. He places the patient in the knee-elbow position and makes the injection for choice at the site where the gluteus maximus crosses the long head of the biceps, as there the nerve is most easily reached and without risk of doing damage. As soon as the needle, which is some 7 to 8 cm. long, touches the nerve, it sets up severe pain shooting down the limb, and thereupon the fluid is injected. Following this procedure, rest in bed is desirable for a day or two, as in many cases fever and malaise are found to occur, but these conditions pass off within a very short period.

Treatment by injection is held by Bum to be indicated in all uncomplicated cases of true peripheral sciatica, subacute and chronic, but not if marked arterio-sclerosis is present. According to individual necessity one to four injections are given with intervals of several days. Out of sixty-seven cases so treated

complete recovery ensued in forty-two (= 62.6 per cent.), and in other fourteen notable benefit was obtained.

II.—Diseases of the Spinal Cord.

(a) SYSTEMIC AFFECTIONS.

Tabes Dorsalis, Locomotor Ataxia.

Even in the earlier stages of locomotor ataxy there may be found to develop those peculiar alterations of the bones and joints, which are known as *tabetic arthropathies* and *tabetic spontaneous fractures*. The etiology and mode of occurrence of these affections are now considered by the majority of authorities, as by Charcot in his time, to consist in a trophic disturbance of the bones and joints brought about by the affection of the spinal cord (see Adler). In support of this theory there are cited investigations which have demonstrated in tabes degenerative changes in the peripheral nerves and even in the articular nerves when the joints were involved (Oppenheim and Siemerling, Dejerine, Westphal, and others). But since every joint does not become diseased in the extremity of which the nerves are affected, and since, moreover, other pathological conditions also manifest nerve degenerations, such as chronic tuberculosis, inanition, senile marasmus, brain tumours, &c., but without the occurrence of such osseous changes, it is advisable not to neglect the view held by Virchow, that mechanical and thermal influences are responsible for the causation of the affections of the joints.

The joint which is trophically impaired may be injured by influences which perhaps would leave no

trace behind in the normal condition, and a fracture of the bone may occur "spontaneously" because the patient is unobservant of an actual trauma owing to his defective sense of pain. It is therefore not always easy in the particular case to decide whether the accident, as for instance, a wrench of the foot, has caused a fractured ankle, or if a spontaneous fracture at the ankle resulted in the wrenching of the foot. Tabetic affections of the bones therefore may be a source of much difficulty, not only in the diagnostic, but also in the forensic aspects of the case. Thiem points out that fragility of the bones is often one of the earliest signs of tabes, and may be present before the disturbances of sensibility, ataxic gait, and loss of the patellar reflexes. On this account an atypical commencement of a tabetic arthropathy may lead to errors with serious consequences (Blencke).

As a rule the tabetic *joint disease* starts acutely. Frequently the patient can offer no reason for the origin of the disease, while an injury which he has possibly sustained stands in no relation to the severity of the manifestations. Occasionally the patient has noticed creaking in the affected joint for some time previously. The knee is attacked the most frequently, then, in sequence, the hip, shoulder, elbow, spine, foot, hand, and in rare cases, even the jaw.

In the course of a few days or even hours a notable swelling of the joint develops, and this may extend to the adjacent tissues or even involve the whole extremity. Apart from exceptional cases the swelling has not the character of an ordinary œdema, being much more firm, so that the pressure of the finger hardly leaves an impress behind. Rotter ascribes this state of affairs to

deep-seated œdema of the soft parts. The skin over the swollen joint is tensely stretched, and pale, and the veins traversing it are sometimes dilated. As a rule then there is no reddening of the skin, and there is accordingly no rise of temperature of the part. On examining the joint one frequently finds loose bodies of various sizes and detached portions of the articular ends, which fact gives support to the view of many writers (Rotter and others), who are not prepared to admit a sudden onset of the arthropathy, but only of the marked swelling, which is led up to by previous changes in the joint. These changes are not perceived on account of the disturbance of the deep sensibility. Tears of the capsule or fractures in the joint are the immediate causes of the articular swelling. This assumption is borne out by the fact of the joint fluid being often largely mixed with blood (Dufour). The usual complete absence of pain is very astonishing in face of even the most marked objective signs of disease of the joint. The patients consult their medical attendant only because they cannot comprehend the sudden appearance of the swelling without evident cause. They are able also to use the affected limb for quite a long time without restriction, and are only disabled when at last serious deformities of the joint ensue.

In many cases, with suitable treatment and care, the more alarming features retrocede, the swelling and effusion pass off, but in the majority the disease continues its progress. Atony of the capsule and ligaments follows, and sooner or later a flail-joint is produced, and it may be in an extreme degree. At the same time there is destruction of the articular ends, and this, combined with the articular fractures which may

occur, can give rise to the most varied deformities. Thus one may see in the case, for instance, of the knee, a condition of *genu valgum, varum,* or *recurvatum,* as well as lateral *dislocation of the leg* (Wilms, Urbach), backward *dislocation of the tibia* (Wilde), and in the case of the hip, *spontaneous dislocation of the femur.* In an instance of this last kind the patient, in spite of severe distortion of the joint, had no consciousness of it (Oppenheim).

Further disorganization of the ligamentous structures and destruction of the articular ends result from *atrophic* and *hypertrophic* processes. The cartilage of the joint is destroyed, the bone absorbed and smoothed down in correspondence with the pathologically altered transmission of body-weight, or new formation of bone may take place. Bony processes then form on and near to the joint surfaces, in the soft parts surrounding the joint, and most curiously formed bony outgrowths extend into the capsule, the tendons, and the muscles. Loose bodies appear in the joint, partly from spontaneous fractures of the ends of the bones, partly from breaking-off of the newly formed excrescences. In the skiagram one may further see evidence of eburnation, rarefaction, and lipping of the cancellous bone.

Although the disease picture has a certain resemblance to that of arthritis deformans, it differs from that indeed chiefly in respect of the almost complete absence of pain and the occurrence of the characteristic, extensive intra-, peri- and para-articular changes of the joint, which, as seen in the skiagram, may allow of a correct diagnosis even when other indications of tabes are lacking (Kienböck). The lesions above described, which characterize the atrophic and hypertrophic forms

of the tabetic arthropathy (Adler), are found in association in the knee-joint; while in the hip and the shoulder the atrophic form chiefly is found, in the elbow and foot, chiefly the hypertrophic form. Usually not merely is one joint attacked by the arthropathy but several, in which event it is very frequent to see the joints symmetrically involved on the two sides. As already indicated in the list given above of the order of frequency of the joints affected, the lower limbs are much more frequently attacked, accounting for 80 per cent. of the number against 20 per cent. in the upper extremities (Rotter).

It has been mentioned already that fractures within the joint occur in this affection and that indeed such fractures are occasionally the *cause* of the trouble in the joint. Even by careful treatment it is not always possible to guard against such injuries, for fractures have occurred in patients confined to bed. Blencke has seen recovery, without the use of splints, from a double fracture of the ankle without subsequent disease of the joint, and Oehlecker has seen a similar case.

Fractures of the *bones* away from the joints resemble the arthropathic conditions in their absolute painlessness. The bones of the patients break as a result of quite trivial accidents. A patient of Blencke, for instance, had the neck of his femur broken as he was lifting his hat from off the peg; another broke his leg when watering flowers; the external rotation of the leg in pulling on a boot caused fractures of the leg and thigh, and simply sitting up in bed gave rise to a fracture of the forearm.

These fractures, as mentioned above, are often an *early symptom* of tabes. In a case of Oppenheim,

even eighteen years after a spontaneous fracture of the femur, only the initial symptoms of tabes were in evidence. A spiral fracture of the femur from external rotation was observed by Tilman, and he later found experimentally that it was not possible in the normal bone to produce a spiral fracture of the femur by means of levering on the leg. Apart from the extremities, spontaneous fractures have been noted in the pelvis and the mandible.

The altered sensibility of bone has been held specially responsible for the occurrence of spontaneous fractures, for the "sensibility to vibration" or "pallæsthesia" [9] is often diminished at an early stage (Oppenheim, Egger, Seiffer-Rydel). Speaking generally, one must look for the chief factors in the causation of tabetic spontaneous fractures in the loss of muscle tone, the absence of muscular sense, and of osseous sensibility, and the consequent difficulty which the patient has of judging properly the state of tension of his muscles, the weight borne by his bones and the extent of the traumatic force applied (Baum). A further point to be noted is that atrophy of disuse may affect the bones in a long drawn-out illness and great fragility is, of course, the result.

These fractures often unite excellently, but sometimes only very slowly; the callus thrown out may be at times slight, at other times profuse, while occasionally the formation of a false joint is to be observed.

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[9] Pallæsthesia is the sensibility of the bones or periosteum to vibration as tested by aid of a tuning-fork. In its nature it is related to the general deep sensibility, bone being merely a better conductor of vibration. Seiffer and Rydel have found the sensibility altered most commonly along with loss of the sense of position and ataxia, and also with loss of the sensibility to pain and temperature.—Translator.

The *foot* in tabes may present a peculiar deformity due to the pathological changes in the bones and joints. This condition was first described by Charcot and Féré in 1885 as "*pied tabétique.*" When seen in an advanced stage of the disease it is found, as described by Adler, that the foot is already markedly enlarged. The skin appears œdematous but does not retain the impression of the finger tips. An actual flexion of the foot at the tarso-metatarsal articulations either inward or outward is very characteristic. There is consequently a striking projection, usually showing on the inner border of the foot. The scaphoid and internal cuneiform, as also the remaining bones of the tarsus, are greatly enlarged, so that the arch of the instep becomes less and less evident, and not infrequently a severe condition of flat foot results. Only in rare instances does it happen that the arching of the foot becomes exaggerated. There is found to exist a sclerosing, but principally a rarefying osteitis in the joints of the foot, the former condition being evidenced by the development of osteophytes and exostoses, the latter by partial destruction. The thickening of the periosteum and the hyperplasia of fibrous tissue may completely envelop the bones in places, making them unrecognizable (Leguen and Deverre).

Fractures of the *tarsus* likewise result under the influence of strains. Fracture of the head of the astragalus is described by M. Levy as typical, and should this happen, the broken-off head of the bone is pushed in the direction of least resistance, that is, toward the dorsum of the foot, so that the prominence formed by this portion of bone gives an appearance of arching to the foot, though that is not actually present.

The smaller joints of the foot also undergo alterations, analogous to those described above, associated with processes of either hypertrophy or rarefaction. In a case of Senator, the foot was flat, shortened, thickened, and rounded off. The tabetic foot is a comparatively rare occurrence, constituting 4.75 per cent. of the number of tabetic arthropathies according to statistics of Pansini.

A somewhat rare site for the appearance of tabetic osteo-arthropathy is afforded by the *spinal column*. One finds polished surfaces on the articular aspects of the vertebræ and osteoporosis of the vertebral bodies, as well as, on the other hand, hypertrophic conditions of the vertebræ and their processes, and in addition new bone formation alongside the spine, thus distinguishing it from arthritis deformans. As seen in a skiagram, the atrophy is shown by a peculiar indefinite paleness of the shadows of the bones in contrast with the marked sharpness of their contours (Sudeck, Von Leyden, Kienböck, Frank, and others). The spongy cancellous bone is rarefied, the compact bone broken up (Exner); at the same time there may be also partial new formation of bony lamellæ. Compression fractures may occur in the bodies of the vertebræ spontaneously or from the effect of strains. The clinical picture varies correspondingly. If a considerable number of vertebræ are equally involved one finds kyphotic or kypho-skoliotic curvatures of the spine. These are due to the crushing of the osteoporotic vertebræ in front, at the back or at the sides so that they take on a wedge shape. The intervertebral discs are also involved in the compression. These changes are most commonly found in the lowest dorsal and lumbar regions. The form of curvature is

dependent on the customary attitude of the patient, and is followed by the development of compensatory curves in the spine.

In spite of increase of size of the diseased vertebræ the slightest injuries are capable of causing their fracture, but this is mostly observed in the lumbar vertebræ which are usually attacked by rarefaction. At the site of the fracture a hump may be formed or an already existing deformity may become rapidly augmented. In a case of Frank, the spinal column presented a kypho-skoliotic curve, but was at the same time freely movable. The patient had no pain, although there was serious injury of the second and third lumbar vertebræ. The second vertebra was displaced downward to the right, and the third vertebra upward to the left, while in addition both were comminuted and crushed. This sliding displacement or fracture-dislocation of the injured vertebræ, known by the name of *spondylolisthesis*, was first fully studied by Krönig, and Watkins has also reported a case of tabetic spondylolisthesis after fracture of the fifth lumbar vertebra.

The hypertrophic changes mentioned as occurring in the vertebræ are chiefly evidenced in lipping of the margins, which thus extend over the intervertebral discs to unite with those of the adjacent vertebræ similarly lipped. The capsular ligaments of the articular processes may also ossify and likewise the ligaments of the spinal column. As a result the spine becomes still more stiff, especially when bony deposits form in the neighbouring muscles. These new bone formations, if extensive, may serve to prevent compression of the spinal cord should spontaneous fracture occur, in that they furnish a support which tends to restrain the

fractured vertebral bodies from being severely dislocated. When the ossification around and close to the vertebræ is but slight, and therefore more or less mobility of the spinal column is retained, the irregular apposition of the joint surfaces is demonstrated by the existence of crepitus which can be heard and felt when the spine is moved.

The *prognosis* in the tabetic osteo-arthropathies is unfavourable in view of the general disease. As Möbius says: "Apart from the fact that a fracture of bone or a diseased joint is in itself a serious matter, which may greatly prejudice the patient by restricting his activities, the important consideration is that these conditions are very frequently multiple, because the deleterious influence on the bones is more or less general in action."

This consideration furnishes a rule for guidance in regard to the *treatment* of the disease. Any extensive operative procedure involves danger. To confine the patient to bed for any length of time is to run the risk of bed-sores and cystitis; while on the other hand, one has no guarantee that, after operation on some part of the skeleton, the specific pathological processes may not start afresh and so negative any beneficial result. This proved to be the experience of König, who found after resections of joints that frequently the bones would not unite but formed false joints, leaving the limb more flail-like than before.

In certain circumstances amputation may be preferred as a more satisfactory procedure than resection. Still, as Ullmann points out, in deciding as to operation the severity of the causal disease is a factor of importance in addition to the state of the joint itself, for one must

take into consideration whether the condition of the disease of the spinal cord will permit of the patient going about after even a successful operation.

When sudden swelling of a joint occurs it is to be got rid of by keeping the limb at rest by applying firm bandages, after perhaps first of all tapping it. The joint can be kept at rest in the acute stage most simply by a carefully applied plaster-of-Paris bandage. Later on it is better to have a supporting sheath splint appliance made up from a plaster model, and this is also necessary if resection has been performed [10]. An apparatus of this kind is specially effective if it protects the joint from the injurious mechanical influences to which the ataxic inco-ordination of movement exposes it. As Hoffa also has emphasized, the patient with the help of the

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[10] Sheath splint appliances are frequently referred to throughout this book. They are sometimes described as Hessing's apparatus, after the mechanic who devised them, and they are nowadays generally employed where orthopædic splints are required, if the cost is not prohibitive, for they are expensive to purchase. The apparatus is made of leather or celluloid accurately moulded to fit the patient's limb. Metal bars are attached so as to strengthen each portion of the sheath, and the various parts are united by hinges between the ends of the bars. These joints can be made adjustable to suit the needs of the particular case.

It is of great importance that orthopædic appliances of this kind should be fitted accurately to the patient. To ensure this, a light plaster model of the limb is first made, and this should be done by the medical attendant. The limb, placed in proper position, is covered with a tubular stockinette material, and plaster bandages are closely applied over this to form a light mould. When the plaster is firm, but not yet hard, the bandage is cut in two at front and back with a knife, and the instrument-maker prepares the finished splint from this mould.

These sheath splints have the advantage of being comfortable to wear and efficient in action, because the pressure is uniformly distributed, and the best possible support is obtained thereby.—Translator.

appliance walks with more feeling of security, since the tendency to any injurious movements in abnormal directions can be stopped or perhaps anticipated and prevented. Thus, for instance, one may have the hinge at the knee-joint so adjusted as to prevent hyperextension, or, it may be, to correct a condition of genu recurvatum already existing. In addition to restoring the proper limits of movement of the joint, it may further be deemed necessary in such a case to make use of sheath splinting apparatus or plaster bandages so as to prevent strains on the diseased joint. By such means the constant friction of the articular surfaces on one another may be put a stop to, and thereby the state of mechanical irritation which leads to wearing down of cartilage and bone and to proliferation.

This is the method by which one can most rapidly bring the disease to a standstill, and the influence of a supporting corset in a tabetic arthropathy of the spinal column is equally favourable. This appliance acts not so much by preventing strains as by fixation, and it proves its value in the relief which it affords from the discomforts arising in the progress of the disease, while it may also stave off the more severe calamities. Moreover, when wearing the supporting corset, which, of course, must be made up to the pattern of an exact model, the patient enjoys a feeling of assurance, for his body is now prevented from collapsing in its previous helpless fashion. As a result his mental outlook is favourably influenced, and this explains the great success attending the use of a corset, that is seen sometimes in patients with severe ataxic symptoms, even when free from spinal arthropathy.

One is frequently called upon to prescribe some form

of supporting apparatus or a suitable boot for a tabetic patient whose foot shows a tendency to be twisted to the side, thereby incurring the risk of a fractured ankle or some other serious injury to the foot. The application of a corrective and supporting apparatus may be rendered necessary also in some circumstances, when there is loss of tone (hypotonia) in the muscles, allowing of marked over-extension of the knee-joint (genu recurvatum). Although by such means certain calamities caused by locomotor ataxia may be excluded, still, in the proper management of the ataxia, the part of first importance does not consist in the use of these appliances, but in the adoption of the compensatory treatment of re-education by exercises, a method devised by Frenkel, and developed and established by Foerster, Goldscheider, and others. In so far as certain deformities in tabes result from the ataxic conditions, *e.g.*, genu recurvatum, which arises from the great backward strain on the limb in walking when bearing the weight of the body, the treatment of the ataxia also serves as an efficacious means of combating these deformities.

Acute Anterior Poliomyelitis, Infantile Paralysis.

Acute anterior poliomyelitis is a veritable scourge of childhood, for while it exacts comparatively few fatal results, it condemns the children attacked to be life-long cripples.

In the absence of a specific remedy for the causal condition, our therapeutic endeavours must be limited to restricting the paralysis of muscles as far as possible, and in the next place to preventing the development of deformities. The former of these requisitions is met by a careful fostering of the muscles, in the endeavour to

retain even the smallest traces of the power of movement in them. Electricity, massage, and warm baths are employed with advantage to increase the muscular activity. As a further assistance gymnastic treatment finds a place. By this means one seeks by systematized exercises to strengthen the capacity of the muscles as power returns to them. As this increases, one substitutes movements against resistance for the simple exercises. Hoffa has advocated regular exercising with swinging weights. Appliances so designed have the advantage that movement may be produced by the patient at those joints which he cannot voluntarily move. By such means the paretic muscles are enabled to contract, the movement of the weight acting in the same direction, and thus helping whatever small activity they may still retain to be brought into play. Another feature is the opposition offered in this way to the development of contractures. When a group of muscles is paralysed, any nerve impulse produces only a contraction of the antagonizing and functionating muscles, while these latter are never extended since the paralysed muscles have no counteracting effect. If this state of affairs is allowed to persist, gradual shrinking, which becomes permanent, takes place in the contractile muscles, and with unfortunate consequences. By the aid of the swinging weight the function of the paralysed muscles is replaced for the time being at least, and a resistance is offered to the shortening of the antagonistic group of active muscles. If a pendulum apparatus of this kind is not available, one must endeavour to counteract the tendency to contracture by corrective movements carried out manually in the lines of action of the paralysed muscles.

There are other factors which account for contracture or, it may be, deformity that require consideration, besides the antagonistic action between paralysed and non-paralysed muscles (Seeligmüller). When the control of movement and of stability is lost to a part of the body as a result of paralysis of the muscles pertaining to it, deformative changes may readily occur owing partly to its own weight and partly to any strain brought to bear on it (Hueter). For example, if a child with a paralysed foot lies in bed, the foot will drop, taking up a position of adduction and supination, and this constitutes the initial stage of a club-foot of the equino-varus type, while the simple pressure of the bed-clothes is capable of hastening the deformity. These prejudicial influences being continuously at work cannot be counterbalanced by the gymnastic exercises temporarily carried out. Without neglecting the latter, one will give thought to the means available for establishing a constant resistance to the influences which tend toward deformity. Taking the example mentioned, we may assume a paralysis of the flexor muscles of the foot, in which event contracture of the calf muscles will still further contribute to the formation of a club-foot. In order then to counteract the constant influence of the weight of the foot itself, likewise of the bed-clothes on it and the harmful contracture of the gastrocnemius and soleus, we should employ for the purpose a suitable device which would serve to support and rètain the foot in the normal position. For this object we can use a splinted leather sheath apparatus made to the pattern of a plaster mould and fitted with rubber bands acting in the direction of flexion of the foot (fig. 27) [10a].

[10a] See p. 145.

But a quite simple appliance giving good results, which serves to fix the foot in a slightly over-corrected position, is constructed in the following way: Two lateral splints are fitted to the leg, united to each other by a semicircular metal band, and a foot-plate is attached to the splints so that the foot when bandaged to it is retained in a slight calcaneo-valgus position (flexed and pronated). The manufacture of a plaster-of-Paris splint is still simpler. A trough is moulded to the limb with the foot in the position just mentioned, and the foot and the leg are bandaged to it. Paralysis in any other part of the body is treated prophylactically on similar principles and by like methods.

As soon as the patient is once more able to get about, it is necessary to consider the application of a suitable supporting apparatus, to prevent, or at the worst to retard, the further occurrence of deformities. Supporting splints should be fitted with rubber bands corresponding to the distribution of the paralysis, so as to oppose the antagonistic muscles (figs. 27 and 28) [10b]. They should be devised so that the support they afford to the paralysed limb may restrict the prejudicial influence of the burden and strain of the body-weight.

Should the disease be so serious as to leave the legs completely paralysed, an apparatus is then unavoidably necessary as a means of making locomotion at all possible for the patient, to avoid the alternative of supporting the whole weight of his body by his arms on crutches. There is, moreover, the consideration that in the latter case two strong healthy arms are a necessity, and the arms would be useless if they had been also involved in the paralysis. A pair of accurately fitting

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[10b] See pp. 145 and 149.

sheath splints are made up, which are locked at the knee by a spring catch when the patient is standing or walking (fig. 24) [10c], and so prevent any collapse at the knee-joint. A slight pressure on the spring catch allows the apparatus to be bent at the knee so as to let the patient sit more comfortably. As soon as he rises up, the catch becomes automatically locked and fixes the limb in the needful position of extension. If the musculature of the hip-joint is also paralysed, the patient would collapse at the hip-joint even with the knee fixed. A pelvic girdle is therefore attached to the sheath-supports of the limbs, and the extension of the hip-joint is thus maintained. Sometimes one can make things still more easy for the patient if, in place of the pelvic girdle, one has fitted a supporting corset connected directly to the leg portions. The stays, again, may be a necessary addition if paresis of the muscles of the trunk is also present, in which case the corset must be provided with arm supports at the axillæ.

As a very rare occurrence in poliomyelitis one may find the **sternomastoid** paralysed. A *wry neck* results if but one side is affected. The head can be rotated passively to the unaffected side but not by voluntary movement. All attempts at movement of the affected muscle demonstrate the absence, on the convexly curved side of the neck, of that prominence of the sternomastoid muscle which it presents normally, and also in the case of congenital wry neck. If the paralysis does not pass off under treatment, then permanent contracture results in the sternomastoid of the opposite side and the wry neck becomes fixed. It is therefore obviously necessary to commence corrective exercises with the head without

[10c] See p. 131.

delay, and to assist these measures by the wearing of a supporting collar (fig. 22). If contraction of the healthy sternomastoid has already set in, tenotomy must then be performed and treatment carried out as for congenital wry neck.

As regards the **upper extremity,** in paralysis of the **shoulder girdle** prophylactic measures are necessary first and foremost. The capsular ligament of the joint becomes lax when the deltoid and the external rotators of the humerus are paralysed, as these muscles also serve to brace the joint. The capsule becomes more and more stretched owing to the weight of the dependent

FIG. 22.

arm, and a subluxated position of the head of the humerus is the inevitable result. The appearance of a shoulder which presents this paralytic dislocation is a highly characteristic one. With the sinking-down of the head of the humerus the soft parts covering it are driven in against the empty glenoid cavity by atmospheric pressure, so that the sharp prominence of the acromion is separated by a depression from the rounded prominence over the head of the humerus. Further,

the arm takes up a position of internal rotation with the hand pronated, especially marked when the internal rotators of the humerus are intact. By pushing the arm upward the head is replaced in the glenoid for the time being, only to become luxated again when the arm is left to drop by its own weight. The condition is one then of marked flail-joint.

From these conditions it is at once apparent what preventive measures it is necessary to take during the period of paralysis and convalescence of the shoulder muscles. The head of the humerus must be prevented leaving its socket, and this is ensured most simply by the use of a sling which transfers the weight of the arm to the opposite shoulder. At the same time electrical treatment, massage, and exercises must be directed to restoring the muscular function as far as possible. Schüssler has employed a shoulder-ring for the fixation of the head of the humerus. Three air pads are attached to the inner aspect of the ring, one in front and one behind the shoulder-joint, and one in the axilla. Heusner supports the arm by means of a spiral of wire, which is fixed to a leather mitten and to the axillary support of a corset. Hoffa recommends a cap for the shoulder and upper arm, similar to Billroth's apparatus. The sheath enclosing the upper arm is continued over the back of the elbow and thus secures the arm to the shoulder. To take the place of the deltoid, a rubber band is attached above and in front of the sheath and passed over the shoulder obliquely across the back to the hip-bone of the opposite side, where it is fixed to a corset. Rubber bands passing to the arm direct from a shoulder-cap or shoulder-ring may also be used to steady the head of the humerus against the glenoid.

A partial restitution of the muscular power has been attained in apparently hopeless cases by means of constant elevation (abduction) of the upper arm with the aid of an apparatus arranged to take all strain off the over-stretched deltoid, combined with massage of that muscle (Silver).

When individual muscles of the shoulder remain permanently paralysed, the question arises of replacing them by the transplantation of healthy muscles. Various procedures were discussed previously when dealing with peripheral paralysis of the shoulder muscles. Thus, for instance, good results have been obtained in residual paralysis of the deltoid by the substitution for it of the trapezius (Hoffa) or pectoral muscle (Hildebrand), also by reinnervating the circumflex nerve by means of nerve transplantation (Vulpius).

If the muscles round the shoulder-joint are wholly paralysed, a movement of the upper arm can only be brought about by *fixing the shoulder-joint,* thus transferring the movements of the shoulder-girdle musculature (trapezius, serratus, &c.) directly to the upper arm. This conception naturally pointed the way to the operation of *arthrodesis* of the shoulder-joint. This procedure, which was first employed by Albert in the year 1879, aims at bringing about a very firm and, if possible, osseous union between the head of the humerus and the glenoid. It has been found most advantageous to secure ankylosis with the arm considerably abducted, raised anteriorly and slightly rotated inward. Vulpius has secured in such cases on the average a range of voluntary movement of the arm of about 75° forward, about 60° to the side, and about 30° backward.

For severe paralysis of the **muscles of the arm** there may arise the question of fitting on a sheath support, in which the action of individual muscles, or of groups of muscles, is replaced by elastic bands or spring mechanisms. Some benefit is thus obtained in paralysis of the muscles flexing the forearm by the wearing of a sheath splint, which can be fixed with the elbow at a right-angle by means of a locking catch. This would permit of the hand being made use of for at least the most necessary actions of daily life.

In the treatment of permanent paralysis of the muscles of the arm, in which the condition is usually limited to the extensors, tendon transplantation has been adopted in more recent times with much success, while a rival procedure that promises well has arisen in nerve transplantation. The less that individual muscles are affected by the paralysis, and the more powerful the muscle called upon to act as substitute, so much the better is the result of the operation. The same principle applies also to the transplantation of nerves, *mutatis mutandis*. The operative procedure is similar to that adopted in peripheral paralysis of the muscles of the arm. Accordingly Hoffa has recommended the use of the deltoid in paralysis of the triceps, while Krause and Oppenheim report the transplantation of the deltoid, as also of the biceps on to the triceps.

Alterations in the form of the spinal column result of course when the **muscles of the back** are paralysed. A symmetrical curvature in the shape of *lordosis* takes place when there is paralysis of the long extensor muscles of the back on both sides, but *paralytic skoliosis* is the more frequent occurrence and is consequent on an involvement of the extensors pre-

dominantly on one side. When the extensors on both sides are paralysed, the patient, to avoid tumbling forward, throws his trunk backward in a lordotic curve in the lumbar region, sufficiently far so that the unaffected abdominal muscles in front and the weight of his body behind are in a position to maintain the balance of the trunk. This lumbar lordosis is distinguished essentially by the way in which the trunk hangs over behind from that lordotic curvature of the lumbar region, which depends on paralysis of the *abdominal muscles*. In the latter form the action of the extensors of the back would cause the trunk to fall backward from the normal upright posture. In order to prevent this, the patient contracts the flexors of the hips, thus tilting the pelvis forward, and in this way brings the trunk sufficiently far forward to establish equilibrium between the weight of the body in front and the action of the unaffected extensors of the back.

In both varieties of paralytic lordosis one can benefit the patient by ordering a well-fitting orthopædic corset, which will serve as a relief from the abnormal methods of preserving equilibrium.

It is sometimes found in paralytic skoliosis that the convexity of the curvature is directed toward the sound side, whereas one would expect, as a rule, that the more powerful group of the extensors of the back would contract and accordingly occupy the concave side of a curvature. This phenomenon finds an explanation, just as in the cases of paralytic lordosis, in the fact that the weight of the body is made to take the place of the ineffective, paralysed muscles. The patient projects the trunk toward the paralysed side till the balance is secured as between the weight of the body inclined

toward the side of the paralysis and the contraction of the healthy muscles on the opposite side. If the patient is confined to bed for a long time, the body-weight factor is left out of count, and the shrinking of the better-preserved muscles of the back may bring about a skoliosis in which the convexity is directed toward the paralysed side.

It is necessary to distinguish the paralytic skoliosis occurring *primarily* from those forms which develop *secondarily,* following an attack of poliomyelitis, as a result of the shortening of one of the legs, with consequent depression of the pelvis on the same side. Such shortening of the leg may be due either to retardation of growth, one of the consequences of infantile paralysis, or to some form of contracture such as may ensue from paralysis of the musculature of the pelvis or limb. This *static* type of skoliosis after poliomyelitis calls for correction of the difference in length of the two extremities.

Simple paralytic skoliosis may exist a long time without loss of mobility of the spine and without any very marked distortion, but where the factors that conduce to skoliotic curvature are present one may see just the worst types of skoliosis develop. The weak back must therefore be provided in good time with a support, and accordingly it may be found advisable occasionally during the attack of the disease to direct the use of a plaster-of-Paris bed, especially so when the illness commences with severe pains in the back, as these are favourably influenced by this method of immobilizing the back. Later on, the patient must be supplied with supporting stays, and the muscles of the back ought to be very carefully tended. If we are

face to face with an already developed and rigid skoliosis, an attempt at its correction and mobilization by treatment is necessary, but the results admittedly often fall short of the benefit hoped for.

Paralysis of the **musculature of the hip** determines serious disturbances of function. In the normal gait the muscles participate in the movements of locomotion as follows: The biceps, semitendinosus and semimembranosus extend the hip and are aided in this by the gluteus maximus, while the gluteus medius and minimus abduct the hip and control the lateral equilibrium. At the moment when one limb is raised off the ground preparatory to making the step forward, the area of support to the body is, of course, not only diminished by the lifting of the one foot, but also transferred to the side of the supporting limb. In order to bring the centre of gravity over this, the trunk is inclined slightly to the side of the supporting limb, the pelvis being fixed on that side by the gluteus medius and minimus. This inclination of the trunk may be almost absent in vigorous locomotion; for powerful contraction of these glutei raises the pelvis on the opposite side so far that, without any inclination of the trunk, the centre of gravity of the body is brought over the area of support furnished by the standing limb. Should these muscles elevating the pelvis be paralysed however, then, when one leg is raised, the pelvis sinks on that side, and to prevent the trunk falling over to that side it must be thrown well over to the opposite side on which the weight is being borne. This mechanism of locomotion, brought into play on account of the inefficiency of the elevators of the pelvis, explains the limping gait of the patient.

When all the muscles of the hip are paralysed the capsule of the joint may become stretched, being deprived of its normal muscular supports. This stretching may increase under the effect of the weight of the limb so much, that the articular ends of the bones become separated, though they can be readily brought into contact again. A flail-joint of the hip is the outcome, analogous to the paralytic flail-joint of the shoulder. If some of the hip muscles recover later on, it may be possible for the patient to replace the luxated head of the femur in its socket by voluntary action (Appel, Garavini).

The position of affairs is different when the paralysis has implicated only certain groups of muscles or has but partially affected the other groups. In that event contractures develop in the first place, to be followed secondarily by alterations in position of the head of the femur. If the flexors and adductors possess the dominant power, the hip becomes fixed in a position of flexion and adduction, in which case the capsule becomes stretched posteriorly, and the head of the bone may emerge on the ilium, constituting paralytic iliac dislocation, which becomes further exaggerated by the weight of the body during attempts at walking. As a contrast to this a paralytic infrapubic dislocation may occur, should the gluteal muscles and the rotators of the femur retain their activity while there is paresis of the flexors and adductors of the hip. This form of dislocation may arise, according to Karewski, with the patient lying in bed, if the hip and knee are fully flexed. The weight of the limb is then calculated to increase the flexion and outward rotation induced primarily by active muscular contraction. The weight of

the limb, the long axis of which is now directed inward and downward on to the hip, is acting "so to speak, as a *vis a tergo,*" in the same direction as the pull of the functionating antagonizing muscles, that is to say, a dislocating action. The occurrence of such excessive contracture is to be prevented, of course, by the use of suitable appliances to maintain a correct posture.

Fortunately dislocation of the hip does not present itself as a complication of all paralytic contractures of the hip. Since the tensor fasciæ femoris and the sartorius enjoy a special immunity from attack, flexion contractures are very frequent. These are combined only rarely with adduction. The *typical* paralytic contracture of the hip is one of *flexion* and *abduction.* With this there is usually associated contracture of the knee and of the foot as well.

The *treatment* of fully developed, but uncomplicated, contractures consists in forcible correction, preceded by subcutaneous tenotomy or myotomy of the contracted soft parts. In specially difficult cases subtrochanteric osteotomy of the femur may also be considered. The corrected position is maintained by means of a plaster-of-Paris bandage, and when this is dispensed with, a hip sheath splint should be worn for some time to prevent any relapse.

The treatment of a paralytic dislocation is carried out on the same lines as that of a congenital dislocation of the hip. Since it is impossible to rely upon the stability of the head of the femur after reduction, it is necessary to make the patient wear subsequently a supporting sheath splint round the hip.

When the gluteus medius and minimus, which support the pelvis, are defective, it is an almost insoluble

problem to find a means of replacing them by transplantation of healthy muscles, since the demands put on these muscles in standing and walking for the bearing of the strain of the body-weight are exceptionally great. Lange, indeed, has attempted to make use of the vastus externus as a substitute, by attaching it to the crest of the ilium by silk sutures, but the result was not satisfactory. A complete *osseous* union between the head of the femur and the acetabulum would be desirable in such cases, just as in flail-joint of the

FIG. 23.

shoulder. Given such a rigid union the pelvis would not then sink to the one side at each step, and the cause of the limping would no longer be present. Unfortunately, an osseous union between the head and its socket, which would be wholly unyielding, is not attainable with certainty by means of arthrodesis. One must, therefore, content oneself with supporting apparatus. Lorenz employs with success a sheath round the thigh with supports on each side of the pelvis (fig. 23). These latter serve the purpose of gripping the pelvis

and preventing it sinking down when the weight is carried on the weak limb. For paralytic flail-joint Hoffa uses a corset for the trunk with a sheath splint for the thigh, and these are joined together. Opposite the hip-joint there is fitted an automatic locking catch, so that the patient, when standing or walking, can fix the joint, or release it for greater comfort in sitting.

It has been shown above how important a factor is the strain put on the pelvis by the upper part of the body when the power of the elevators of the pelvis (the glutei) is defective. In the **lower extremity,** too, the factor of weight frequently determines the direction and extent of paralytic contractures. Accordingly we have to judge of the consequences of a loss of function in the musculature of the lower extremity from points of view quite different from those in the case of the upper extremity. In the latter the muscle performs its duty with only the weight of the arm itself to influence it. In the former case the weight of the body is a more important factor in putting a strain on the limbs. The body-weight may assist a muscle in its function if the two act in the same direction, but if acting contrarily it is a powerful antagonist. Since the muscles of the lower extremity contribute their most important services in standing and walking and any other sort of locomotion, the effects of the loss of muscular function and also the chances of replacing the same can be properly estimated only by taking into account the influence of the body-weight. To take just one illustration then, in musculo-spiral paralysis, to be able to compensate for the paralysed extensors implies a complete success. The hand may perhaps not come up to the sound one in mere muscular strength, but yet the restitution of

an important group of muscles enables it to carry out those finer manipulations for which the hand is required. If, on the other hand, we have performed a transplantation in a case of paralysis of the **quadriceps muscle,** with the result that the patient, when lying or sitting, can voluntarily extend the leg to some degree, but not, indeed, to the full amount of 180°, still this improvement is insufficient, if, on attempts to stand or to walk, the incompletely extended knee threatens to collapse under the weight of the body. The weak quadriceps is in such case incapable of overcoming the weight of the body acting against it. A natural conclusion from this is that, in cases of paralytic conditions and of the consequent deformities in the lower extremity, the body-weight should be made use of for the assistance of paretic muscles or, indeed, be actually made to act as a substitute for the lost muscular power, a procedure which one might very well entitle "mechanical transplantation."

In what fashion this might be attained in the case instanced above of paralysis of the quadriceps extensor muscle, is to be learnt from the study of patients who retain the power of locomotion, although paralysis still exists and has not been surgically treated. Cases of this kind come under observation while suffering either from complete paralysis or from paralysis of the flexors of the knee with the quadriceps still functional. It was Volkmann who first of all showed, by the following striking illustration, how to appreciate the mechanical conditions. "Take a pocket-knife in your hand and hold it with the point sticking in the table, the back of the knife turned away from you. The blade then corresponds to the leg, the hinge to the knee, the

handle to the thigh, your hand which rests upon the handle to the body of the patient. As you can at once see, you may now make the blade move at the hinge by means of slight alterations in the direction of pressure. Everything depends on how the strain, which is represented by the weight of your hand, may come on the pin at the hinge. If the strain falls behind it, that is on the cutting side, the knife shuts up if you press down too hard. If the strain falls in front of it, then the knife opens, and when it is quite open you can lay full weight on the handle."

Just as with the handle on the bent pocket-knife, so can the weight of the body act on the knee in quadriceps paralysis in the capacity of an extensor muscle, if the weight of the body is thrown forward. The patient, therefore, when advancing the weak leg, inclines the upper part of his body so far forward that the perpendicular from the centre of gravity falls *in front of* the transverse axis of the knee. Inasmuch as the patient, to avoid collapsing, brings his leg into the position of extreme extension when walking, an over-stretching of the knee may result, the condition of genu recurvatum. Locomotion with extended knee is possible even when the whole of the muscles controlling the knee-joint are paralysed. In this condition the extension is maintained by the body-weight acting in front and the resistance of the posterior part of the capsule and the ligaments acting behind.

It is much more common to find the power of locomotion retained in quadriceps paralysis in association with a slight contracture of the knee (paralytic genu flexum). This position is dependent on the power of the flexors of the knee being at least partially preserved.

These muscles are included in the number of the relatively immune muscles in poliomyelitis, similarly to the tensor fasciæ femoris, the sartorius, the psoas, and the extensor proprius hallucis, and they are capable of restraining the tendency to over-extension and may even produce a position of flexion. Patients suffering from quadriceps paralysis with slight contracture of the knee walk in just the fashion described above. They bend the body somewhat forward, thus adjusting their centre of gravity in the manner necessary, and in this case the strain from the weight is met by the contracted hamstring muscles, which prevent hyperextension.

Walking is certainly seriously impeded if the flexion is marked. The body has to be thrown well forward, so that the patient, when taking a step with the lame leg, makes a sort of a bow, and in addition has to make pressure with the hand of the same side against the thigh to assist in the extension of the knee.

To explain this state of affairs it should be added that in Volkmann's experiment with the pocket-knife both ends of the knife, the point resting on the table as well as the handle held in the fist, are properly steadied. As regards the leg we must premise a proper fixation of the hip and ankle joints, which constitute the ends of the two levers, the thigh and the leg. Since the extension of the knee or, it may be, its maintenance in a slightly flexed position, is dependent on the proper mutual stability of the pelvis on the thigh and also of the leg on the foot, it follows of necessity that the gluteus maximus and the gastrocnemius and soleus must be efficient, if the patient is to walk easily.

A further difference between Volkmann's example and the mechanism of the paretic knee consists in this,

that the hand acting on the knife in producing extension represents an external agency, whereas the patient has to employ his own body-weight for the extension of the knee and at the same time has to watch over the preservation of his equilibrium. The centre of gravity must be brought over the area covered by the foot bearing the weight, on which account a severe contracture of the knee makes walking impossible, as the patient would have to throw his body too much forward and would tumble down. On the border-line there stand those cases in which the patient causes the body-weight to extend the knee by placing his hand over it, which procedure is alike usually adopted when the gluteus maximus or the gastrocnemius and soleus are defective.

It has been emphasized by Reiner that the gait in spite of paralysis of the quadriceps differs but little from the normal if there is permanent fixation of the foot to the leg in a position of extension. This mode of progression is seen when there is a combination of slight contracture of the knee with a certain degree of talipes equinus. When the patient makes a step no flexion is possible between the leg and the foot, owing to the shortened tendo Achillis being incapable of further stretching. It is, indeed, rather the case that the foot and the leg act together as one arm of a lever, of which the supporting base no longer corresponds to the ankle-joint, but is situated in the region of the heads of the metatarsal bones, which first come in contact with the ground. Just because of this advancement of the basis of support below and the consequent backward displacement of the transverse axis of the knee, the conditions created for the use that is made

of the body-weight are particularly favourable, and the forward projection of the body will be lessened or wholly absent. This natural mechanism may be imitated therapeutically if, in the presence of defective quadriceps action along with slight flexion of the knee, one brings about a fixation of the foot in the plantigrade or slightly pointed position by means of a simple splinted boot, or secures it in this position by operation.

An outward rotation of the affected leg in quadriceps paralysis, associated as it may happen with either genu flexum or genu recurvatum, is occasionally produced by a contracture of the rotator muscles of the hip-joint; "it may, however, be attributable partly to an instinctive attempt on the part of the patient when walking to bring the direction of movement at the knee-joint at right-angles to the direction of movement of the centre of gravity, and by this means to oppose more resistance to the risk of the knee collapsing" (Reiner). If we assume that a patient might be able to set the transverse axis of the knee exactly in the sagittal plane and thus oppose to the giving-way of the knee under him the resistance offered by the lateral ligament, it would still be possible for flexion to occur in the coronal plane. In order to avoid both risks and at the same time to derive the advantages of both positions, it is found that the best result is obtained if the transverse axis of the knee is placed in a position half-way between the sagittal and the coronal planes, when compensation of paresis or paralysis of the quadriceps is to be accomplished by means of the horizontal advancement of the centre of gravity (Saxl).

The flexion of the knee is very frequently combined with a valgus position (genu flexo-valgum). This

deformity is sometimes a static one, but at other times one finds a functional weakness of the semimembranosus and semitendinosus muscles while the biceps is intact. Similarly a varus position (genu extrorsum) may develop if the biceps happens to be weaker than these inner hamstrings.

From this consideration of the circumstances in paralysis of the musculature of the thigh and its consequences we are in a position to draw conclusions as to the lines of *treatment* to be followed.

Should we find that after an attack of poliomyelitis the quadriceps is paralysed while the flexors are sound or recovering their strength, we direct the use of gymnastic movements and the placing of a bag of small-shot or sand over the knee every day with the object of obtaining a *slight* degree of hyperextension, which will render the patient capable of walking without any further interference being necessary.

If a flail-joint at the knee is the result after the confinement to bed—and the lax capsule may be sometimes so stretched as to permit of the tibia being subluxated backward by voluntary movement (Hoffa)—we may then employ with success a sheath splint form of apparatus for the limb. The hinge at the knee is fitted with an automatic mechanism, which keeps the leg extended during standing and walking, but allows it to be flexed when sitting (fig. 24). This possibility of altering the position of the knee, according to circumstances, is a better thing for the patient than its rigid fixation by means of arthrodesis. If the hamstring muscles are weakened, as well as the quadriceps, so that genu recurvatum has developed, a similar apparatus is applied and the hinge at the knee is

adjusted so as to allow of that *slight* amount of over-extension which is of help in walking, but to prevent any marked over-extension. Sometimes rubber bands attached to the front of the knee prove useful, replacing to some extent the action of the quadriceps. Of course, one must not forget how important it is to pay constant

FIG. 24.

attention to the state of the muscles, not only to help in the recovery of whatever muscular power remains, but also to avoid the atrophy which the constant wearing of an apparatus tends to produce.

A *slight* contracture of the knee accompanying quadriceps paralysis will not materially impede

locomotion, as has been explained, and the most that is necessary is to try by gymnastic treatment to prevent any aggravation of it. A more *severe* contracture of the knee makes walking impossible and must be remedied. We recommend correction of the contracture by redressment to the extent of a *slight* hyperextension. In children up to about ten years of age one may produce with exceptional ease a partial supracondylar fracture of the femur, in order to make more certain by this means of maintaining the slight hyperextension. If the hamstring muscles are not sufficiently amenable to mechanical stretching, their tendons should be divided subcutaneously. When severe contracture is present and the amount of correction obtainable at the joint is not sufficient, then one secures complete correction by means of supracondylar osteotomy of the femur, which takes the place in older patients of the osteoclasis just mentioned. After the operation the limb is secured by a plaster-of-Paris bandage in the *slightly over-extended* position. The patient is able to go about within a few days and the bandage is kept on for about three months. The after-treatment consists in massage of the quadriceps, that is to say, if it was only affected by paresis, and in placing a weight on the over-extended knee for half an hour daily to maintain the slight over-correction. Thanks to this slight over-extension, the patients can walk very well, holding the body quite upright, and, *of course, without wearing any apparatus,* while the flexor muscles, as they are functionating, guard against an immoderate genu recurvatum.

When genu recurvatum exists with paralysis both of quadriceps and flexors and is accompanied by slight

pointing of the foot, this latter condition must be corrected by tenotomizing the tendo Achillis; otherwise one may expect an undue increase in the recurvation, in accordance with the explanations above given. One will, however, leave the slight pointing of the foot untouched if a contracture of the knee is present at the same time.

We have now to consider the question of replacing the quadriceps muscle by the *transplantation* of healthy muscles. Reiner has laid stress on the fact, in accordance with the investigations of Herz and Bum regarding the "average tractive power" and the "specific energy" of the muscles, that the whole of the flexors together could not produce the effect of the quadriceps, even could they be transplanted to it without loss of power. In addition, a reversal of the deformity might be brought about in such circumstances, for a genu recurvatum might develop out of the genu flexum, since the restraint on over-extension of the knee furnished by the joint structure itself is soon at an end, once the protection of the flexors of the knee is lost. If, then, one is to avoid a marked genu recurvatum, which would render the patient a slave to an apparatus, the transplantation of *all* the flexors is wholly out of the question. At the least *one* powerful flexor muscle must be left in its own place, and the semimembranosus, as the most central, would be the flexor muscle to be retained for preference. Apart from the flexors proper as substitutes for the quadriceps we have the choice of using the functionally unimportant sartorius, the gracilis, and the tensor fasciæ femoris with the fascia lata.

The result of even the most successful transplantation

in quadriceps paralysis does not come up to expectations, so long as the contracture of the knee existing at the same time is not wholly corrected. The correction, and still better the slight over-correction, of the paralytic contracture by itself alone secures for the patient the possibility of a good, upright gait. The absolute correction of the paralytic genu flexum must therefore be looked to as the *most important* indication in quadriceps paralysis, whereas the urgency for performing an additional transplantation of tendons takes a secondary place, although doubtless it is suited and calculated to improve the functional result.

At the same time we hold that after a successful over-correction of paralytic flexure the transplantation of tendons for quadriceps paralysis is only a rational procedure, in the event of the extensor paralysis being *complete* and the flexors being *functionally active*. In the case of mere *paresis* of the quadriceps, transplantation is a *wholly superfluous* interference, since all that is possible is attained much more simply by gymnastics to produce over-extension and by attention given to strengthening the relaxed quadriceps.

In paralytic genu recurvatum Lange has had good results from joining one bone to the other by artificial ligaments of silk. A supporting apparatus is, however, more trustworthy and simpler.

The matter would present itself in a quite different light were it possible to direct new power to the quadriceps by a *grafting of nerves*, without causing injury to other groups of muscles in the process. With this aim Spitzy has tried the central complete implantation of the readily available superficial branch of the obturator nerve on to the anterior crural, but unfortu-

nately the procedure has remained so far unsuccessful, as has also an operation of Van den Bergh, who performed a peripheral complete implantation of the anterior crural on to the sciatic.

Paralyses of the **musculature of the leg** lead to deformations of the foot. The deformity makes its appearance while the patient is still confined to bed, for which reason one must take early preventive measures. Leaving muscular action out of count, the weight of the foot itself causes it to drop down with the toes pointing when the paralysis is complete, since the larger, and therefore heavier part of the foot lies anterior to the transverse axis of the ankle-joint. At the same time the foot twists round, on account of the obliquity of the axis of the astragalo-calcaneal articulations (outward, downward, and backward), with the result that the inner border of the foot appears raised, the outer border depressed. Simply by the effect of its own weight there is thus developed a condition of *club-foot* of the *talipes equino-varus* type. External influences, such as the pressure of the bed-clothes, may hasten the production of the deformity, which tends to become permanent as the bones and soft parts adapt themselves to the new position.

If a total paralysis of the muscles persists, the further fate of the foot depends on what mechanical influences it is exposed to. If the equino-varus position is already fixed to some extent, the effect of weight resting on the foot will be to exaggerate still more the deformity. If, however, the paralysed foot is subjected in an early stage to passive movements in walking, before it has yet become rigid in a particular position, one may expect to find a flail-joint developing without any marked

deformity. Certainly, as a general rule, in complete paralysis no deformity follows. This always develops only in correspondence with the disturbance existing in the balance of muscular action, and it may reach a very marked degree, even with trivial paralysis, while it is usually absent, as mentioned, in complete paralysis.

The influence of weight on the deformation, on which Hueter laid stress, is indeed assisted for the most part by muscular action as well. There may frequently persist some slight traces of muscular activity in the small muscles of the foot—as for example slight movement of flexion of the toes—and also in the gastrocnemius-soleus, though the paralysis is otherwise complete. In the early stage of the club-foot all voluntary impulses would then lead to a further contraction of the calf muscles. Consequently the fibrous contracture of the gastrocnemius-soleus, the condition which follows the closer approximation of its attachments, becomes still more marked and fixes the foot in the pathological position. The formation of the club-foot will take place the more rapidly, the more powerful the extensors and supinators of the foot may be, and the weaker the flexors and pronators. It is in no way necessary that the relative condition of these groups of muscles be such that functionally active supinators are opposed to completely paralysed pronators (corresponding to the antagonistic-mechanical theory of Seeligmüller). Even a slightly preponderating power of one muscle-group suffices to bring about a deformation. We may often observe, for instance, the development of quite serious contractures at the ankle-joint from a loss of muscular power that is hardly perceptible clinically, a proof that even slight

alterations in the muscular balance are capable of producing marked anatomical changes.

If a club-foot, initiated by the effects of its own weight and a predominating action of the supinators, is subjected to the strain of standing and walking, the condition will make further progress, since the weight of the body is now superadded to the factors causing deformity.

It has been mentioned that the predominance of the supinators does not necessarily imply a paralysis of the pronators. Thus there is a peculiar form of paralytic club-foot, the "transitory" (Saxl), the characteristics of which consist in sound calf muscles, paralysed tibiales, and functionating peronei. When the foot is under pressure the contraction of the shortened gastrocnemius-soleus produces a position of club-foot, which the probably paretic pronators cannot overcome, whereas there is merely a pointing of the foot when it is not under pressure, inasmuch as the peronei are then capable of mastering the much weaker supinating action of the weight of the foot itself.

Finally, it may also come about that a club-foot develops even with paralysis of the supinators and extensors, should the weight of the foot gain the mastery over the antagonistic action of the pronators and flexors.

The unceasing activity of the factors which produce deformity results in the *prophylactic treatment* of paralytic club-foot being not always successful in preventing a deformity, even when that is attended to with the most painstaking care and exactness. The methods available are the use of electricity, the exercise of the weakened muscles, manipulative correction, and the

application of some forms of apparatus suited for the day-time and for the night, and fitted with appropriate rubber bands.

The *treatment* of the club-foot demands in the first place the correction of the pathological form. We do not seek to attain this correction by means of a mutilating excision of bone, but employ instead the method of modelling redressment (Lorenz) with subsequent tenotomy of the shortened tendo Achillis. The remodelling operation is considered as complete when the club-foot has been transformed by the manipulation into a slight degree of flat-foot, which is attained by means of a subluxation at the medio-tarsal and tarso-metatarsal articulations in the direction which produces dorsal flexion and abduction of the anterior part of the foot. As a consequence, the direction taken by the tibialis anticus is slightly altered so that, from being as previously supinatory in action, it becomes more impartially a flexor muscle. At the same time the dropping of the end of the foot is prevented.

Fixation of the foot in the over-corrected position for some months, at the same time that it is in active use, has the effect of rendering permanent the result obtained. If one tests the power of voluntary movement in the foot after removal of the bandages, one is frequently astonished to observe that the pronators are now able to produce visible movements, which were not possible in the least degree previous to the operation (figs. 25 and 26). The explanation of this surprising state of affairs is that the lengthened and over-stretched pronators are again placed in a condition to functionate by the remodelling operation, which releases them from tension and restores to them the position which is more

favourable to their line of action. As a deformity develops, the functionating muscles, situated on what one may call the concavity of the deformity, shrink and become shortened, while the weaker muscles lying on the convexity become stretched and lengthened. Even if these are not wholly paralysed originally, and have been damaged to comparatively slight extent, yet they

FIG. 25.

lose all capacity of function because of their state of passive tension and succumb eventually to the paralysis of disuse.

Since the groups of muscles on both aspects of a deformity diminish in power (this applies to all paralytic deformities) the severity of the paralysis is increased by the deformity itself. As the paralysed muscles on

the convexity suffer more than the shrunken muscles on the concavity, the extent of the damage done to the former group increases along with the growth of the deformity. The more marked a paralytic deformity has become, however, the more readily does one get an exaggerated impression as to the extent of the paralysis and the severity of its effect on the muscles. The first and most important indication in respect of a paralytic

FIG. 26.

deformity is for the restoration of the conditions as they existed prior to its development, at least so far as the over-stretched muscles come under consideration. To release them completely from strain a slight over-correction of the existing deformity is to be recommended, and accordingly, in the case of the paralytic club-foot, its transformation into a flat foot.

Lange has already pointed out how important for the

functional capacity of a muscle is its state of elastic tension as between the bones to which it is attached, and that loss of power in a muscle, due to its tone being diminished by stretching, may be made good by the operation of shortening its tendon.

As it takes not a matter of days or weeks but of months at least for the over-stretched pronators to recover, assuming that they were not severely paralysed, it is therefore desirable that if *tendon transplantation* is thought to be indicated it should be performed at a *second operation*, several months after the correction of the deformity has been accomplished. Apart from this consideration, it would be inopportune to perform immediately following the remodelling procedure an operation so delicate and demanding absolute asepsis, in an area for the time-being unavoidably somewhat bruised.

It is not to be expected under any circumstances that a *primary* transplantation of tendons will restore the normal shape of the foot. One must be satisfied if a successful transplantation is capable of maintaining the shape of the foot after correction.

In the after-treatment of the corrected foot, besides the fostering of the muscles, we make use of the weight of the body. The patient is ordered a lacing boot with the sole raised on the outer side, so that he has to place the foot prone on the ground when the weight of his body bears on it. At night the foot is kept in good position by a simple form of support.

Only when there is evidence of a loss or insufficiency of function in the pronators, following a period of after-treatment for several months, is a transplantation of tendons indicated. In this matter one must adhere

closely to the principle, based on experience, that transplantation should only be performed if there are sufficiently capable muscles available for the operation.

One adopts for choice the method of active, descending, complete transplantation in which the functionating muscle is grafted *in toto* on to the paralysed one. Partial transplantation, that is, the use of a strip split off a healthy muscle, has been proved unsuitable. The investigations of Lange in particular have shown that the part of the muscle split off and transplanted does not attain any independent activity. If with the idea of evading this disadvantage one splits it high up, there is again the danger of injuring its nerves of supply. As Wollenberg has emphasized, the chief vessels and nerves in the majority of the long muscles of the lower limb run transversely, and therefore a muscle must not be split up higher than to about the middle of the belly. Further points to note are that as far as is possible only such muscles as are close at hand, as have a similar course, and are related in function should be transplanted, and it is important that the substituted muscle keeps the straightest possible course, and that its tendon is sutured to the paralysed one with the proper degree of tension.

Accordingly one may replace the extensor longus digitorum by the tibialis anticus, if active, and also by the extensor proprius hallucis which usually is functionating. To replace the peronei one uses with most advantage the flexor longus hallucis or the flexor longus digitorum, suturing the chosen tendon in between the two peroneal tendons. Following Lange's plan, one may attach the substituted tendon under the periosteum directly to some suitable points on the bones

of the tarsus, so as to avoid the possible risk of subsequent stretching of the paralysed tendons.

Nerve transplantation is another method which has afforded successful results in paralysis of muscles in this region. Thus Hackenbruch grafted part of the internal popliteal on to the external popliteal (central implantation), and one case after a year and nine months recovered, the peroneal muscles being directly excitable by faradism. Spitzy tried the complete peripheral implantation of the external popliteal on to the internal popliteal in several cases and obtained a more favourable result as regards function than by the reverse procedure. When peripheral implantation, however, is used, there is the annoyance of movements produced sympathetically in the muscles supplied by the active nerve, and Spitzy has therefore recommended central implantation, by which method the regions under control of the two nerves are wholly separated.

If a muscle or nerve transplantation is found to be an inopportune procedure in a case of severe paralysis of the muscles round the ankle after the club-foot has been fully corrected, or should the position of the foot get worse although an attempt had been made to fix the ankle-joint by the plan of suturing the paralytic tendons to the bones of the leg (*tenodesis* of Codivilla-Reiner), then the patient must wear constantly a sheath splint enclosing the leg and foot. The joint of the apparatus is arranged, as for a flail-joint of the ankle, so that only a slight amount of flexion and extension is permitted. The question may also arise as to whether an *arthrodesis* of the ankle should be performed.

The other deformities of the foot which may be a consequence of poliomyelitis are considered and treated

on the same principles as for the paralytic talipes equino-varus.

A pointed foot, the *talipes equinus,* occurs when the flexors are paralysed. Rarely it is found when the foot drops by its own weight, the flexors being sound but the calf muscles paralysed. Occasionally a pointing of the foot takes place to compensate for the diminished growth in length of limb consequent on paralysis.

One seeks to anticipate the occurrence of a talipes equinus in a patient long confined to bed by fitting him with an apparatus as described above for club-foot, to support the foot in position. One may give the patient a piece of bandage passed round the sole of the foot which he can then pull upon from time to time, and even this serves well in controlling the foot. As a further aid one should manipulate the foot daily, bringing it into the flexed position. The apparatus devised by Stromeyer serves the same purpose.

One may employ a sheath splint appliance in the early stages when talipes equinus has developed. The foot portion is approximated to the leg by means of elastic bands to assist in flexion (fig. 27). This apparatus may also be used for walking, in cases of severe paralysis, after the position of the foot has been successfully corrected.

If the pointing of the foot is already beyond ordinary control, improvement is most rapidly secured by means of tenotomy of the retracted tendo Achillis and subsequent remodelling of the foot, and if an abnormal arching or cavus condition happens to be present at the same time it must be also dealt with by modelling redressment.

At a later date, when the plaster-of-Paris bandage is

removed, an operation may be performed if necessary with the object of shortening the flexor tendons, or perhaps for the transplantation of tendons or to produce arthrodesis, procedures seldom called for.

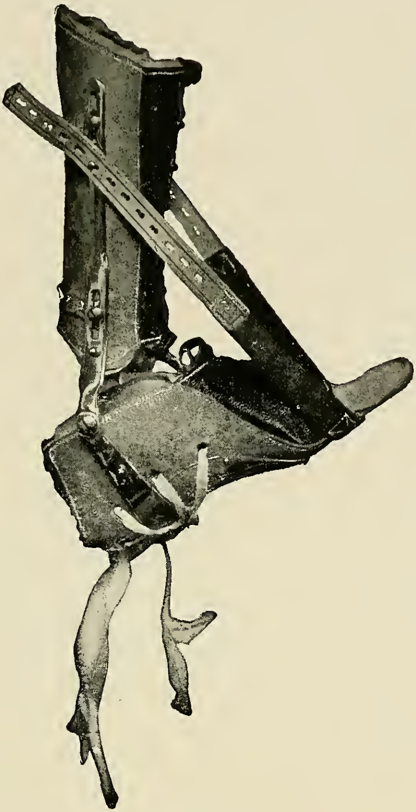

FIG. 27.
(When the apparatus is put on, the elastic bands should be crossed.)

A compensatory pointing of the foot of moderate degree may be left alone. It does not give rise to difficulty in walking provided that the heel of the boot is

sufficiently heightened so as to make up for the shortening of the leg, but if this is considerable a boot of O'Connor's pattern should be worn. This consists of a high lacing boot built up round an artificial foot, the upper surface of which is shaped to the sole of the pointed foot of the wearer.

In paralytic *flat foot, talipes valgus,* the supinators and extensors of the foot are commonly defective, but occasionally the whole of the musculature of the foot may be paralysed. The valgus condition is brought about by the weight of the body alone when there is a general paralysis, but its further development is aided if the pronators retain their function. Even without the influence of weight taking part, a flat foot may result from contracture of the pronators and flexors if functionating, in accordance with the theory of Seeligmüller, in that every motor impulse produces only a contraction of the unaffected antagonists, while they are no longer stretched by the contrary action of the supinators and extensors. The posterior part of the foot assumes occasionally a position of marked abduction from the leg, while the effect of weight acting on the foot each time it is lifted off the ground is to induce a slight supination and varus position anteriorly. The tendo Achillis becomes drawn up following the abduction of the heel, and this occurs also if the arch of the foot becomes inverted under pressure and the heel is thus raised slightly from the ground.

The weakened foot must be provided with a support in good time in order to prevent flat foot ensuing on paralysis. The simplest method is to introduce a good support into a high lacing boot. In addition to supporting the arch of the foot it is also desirable to main-

tain a suitable degree of supination. This latter requirement is met by having the sole and also the heel of the boot raised on the inner side. The support for the arch should be of material which is both firm and elastic, and is perhaps best made of springy steel. It should be made to the pattern of a plaster mould taken of the foot. If this alone is not sufficient to secure the correct position for the foot, one may have a springy splint for the leg attached to the inner side of the support for the sole and projecting somewhat toward the middle line. By strapping this splint portion at its upper end to the leg, the foot is brought into the supinated position. The orthopædic measures are assisted by massaging and exercising the affected supinator and extensor muscles.

If the flat foot is no longer plastic but has become rigid in the deformed position, it is then treated as is the ordinary static form of flat foot by a remodelling operation, and fixed in the corrected posture by plaster-of-Paris bandages. Tenotomy of the peronei when markedly contracted or of a shortened tendo Achillis is frequently found to be necessary.

After the plaster is removed the improvement is to be maintained by the use of suitable supports or appliances and also by methods directed at strengthening the paralysed or paretic muscles. Here again one may discover after the remodelling that the over-stretched, paretic tibialis muscles recover and resume their activity. Transplantation of tendons can usually be dispensed with, as the patients get along sufficiently well with a suitable boot. In any case the prospects of benefiting the condition by means of tendon transplantation are not very favourable. Since we find in

the common static flat foot that the supinators, although not paralysed, give way under the weight of the body, it is hardly to be expected that transplanted muscles should fare any better. In the after-treatment following this operation, a support for the foot is therefore a foremost necessity. According to the conditions present, one would transplant the extensor proprius hallucis or the extensor longus digitorum to take the place of the tibialis anticus, and one of the peronei or perhaps the inner half of the tendo Achillis to replace the tibialis posticus.

Paralytic talipes valgus is frequently found in combination with *talipes calcaneus*. If the latter deformity is the more prominent then, as a rule, the extensors are paralysed while the flexors are sound. The term *talipes calcaneus sursum flexus* is applied when the foot is markedly dorsally flexed. Another type, the talipes calcaneus in the more strict sense of the word, will develop when there is an old-standing paralysis of the calf muscles while the muscles of the sole of the foot remain fully active. In this the foot is not dorsally flexed, but the posterior end of the os calcis is tilted downward by the contracture of the muscles of the sole of the foot in the absence of control exerted through the tendo Achillis. The distortion of the os calcis takes a long time, of course, and the under surface of the foot becomes hollowed out eventually as the result.

For paralysis of the muscles at the back of the leg one employs a sheath splint appliance for the leg and foot, and it is fitted with a strong rubber band passing from the back of the leg to the portion at the heel (fig. 28).

The operative treatment of talipes calcaneus consists

in remodelling the deformed foot, following up this procedure perhaps by a shortening or tenodesis of the tendo Achillis. In tenodesis an attempt is made to fix

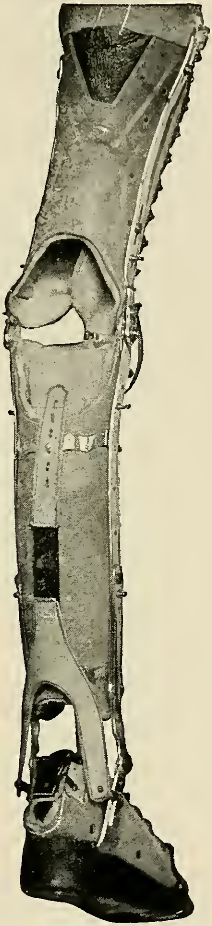

FIG. 28.

the os calcis by attaching the tendon to the tibia, but relapses may follow this method as well, owing to the stretching of the tendon or of its fibrous attachment to

the tibia. But talipes calcaneus is a favourable subject for tendon transplantation in so far as one can replace to some extent the power of the gastrocnemius-soleus by the two active peronei. If the strength of the extensor longus digitorum cannot be depended on, one must make the best of matters by the transplantation of *only one* of the peronei, in order to avoid the risk of a varus deformity ensuing. Although the two peronei together do not furnish a complete substitute for the loss of the gastrocnemius-soleus, still they serve to improve upon the ugly style of walking on the heel.

Slighter degrees of talipes calcaneus associated with pes valgus do not call for any operative treatment as the patients can walk quite well with the help of an arch support for the flat foot.

The condition of hollow foot, *talipes cavus* or *excavatus,* may be found combined with an equino-varus, an equinus or a calcaneus type of deformity. A hollowing of the foot results in talipes calcaneus from contracture of the intact plantar muscles as already mentioned, in talipes equinus and equino-varus partly owing to the weight of the body and partly owing to the forepart of the foot dropping by its own weight. Hollowing of the sole of the foot gives rise to trouble inasmuch as the bearing surface of the foot is diminished and restricted for the most part to the heel and the heads of the metatarsal bones. The severe pressure on the latter may cause very acute pain. This may be relieved by wearing in the boot an exactly fitting support, which enables the weight to be borne also by the part of the foot lying in the hollow, and thus ensures an equal distribution of pressure over the whole of the sole of the foot.

Serious deformities of this nature must be dealt with by a modelling redressment, prior to which the plantar fascia may need to be divided subcutaneously. Even with that, the correction of the condition of hollow foot still presents one of the more difficult tasks of surgical treatment without open operation. Nevertheless it is possible in all cases by means of the remodelling operation to avoid the crude method of resection of bone from the arch of the foot.

Progressive Muscular Atrophy. Primary Myopathy (Progressive Muscular Dystrophy).

The localization of the primary myopathy in the musculature of the trunk, the pelvis, the shoulder girdle, the upper arm and the thigh brings about certain anatomical changes and disturbances of function in the regions affected. The withering of the trapezius, pectoralis, latissimus dorsi, and serratus magnus interferes with the proper fixation of the shoulder-blade, which becomes rotated in a striking manner and appears as if suspended by the levator anguli scapulæ. The shoulders drop downward, forward, and outward. The weakness of the serratus gives rise to the signs characteristic of paralysis, the most obvious of which is the wing-like appearance of the scapula when the arm is raised forward. In addition, the power to raise the arm to its full extent is considerably limited, even when the deltoid is still acting well enough, as the assistance of the serratus is necessary for the full movement.

When the erector spinæ is affected, then, in order to preserve the equilibrium it is necessary for the trunk to be thrown backward, producing a lordosis in the lumbar

region, so that its weight comes to balance with the resistance offered by the abdominal muscles. Another variety of lordosis occurs along with weakness of the gluteal muscles with consequent marked tilting of the pelvis, which again necessitates a lordotic curve of the lumbar region of the spine. Owing to the forward inclination of the pelvis carrying the lumbar vertebræ with it, the centre of gravity of the upper part of the body has to be brought further back again, and this is attained by lordosing the lumbar spine. The static effects are here the same as in the case of the abdominal muscles being affected, and accordingly the position of the trunk is identical. Weakness of the glutei is also the cause of a waddling gait. When the one leg is lifted off the ground the pelvis drops on the same side, and consequently the upper part of the body must be thrown over to the opposite side over the supporting limb. This constant to and fro movement of the body sideways produces the characteristic style of walk.

As the normal functional capacity of the muscles is reduced in proportion to their atrophy, the consequent upsetting of muscular balance may give rise to contractures, which may be explained in the same way as in infantile paralysis on the mechanical-antagonistic theory. Spinal curvatures may form, likewise contractures at the elbow, flexion-contracture of the knee in paresis of the quadriceps, pointing of the foot from contracture of the gastrocnemius-soleus. In the *peroneal type* of progressive muscular atrophy, which commences in the peronei and then also in the extensor longus digitorum and the small muscles of the foot, there develops a club-foot, just as when the same muscular group is affected by infantile paralysis. In addition,

one frequently notices a claw-position of the toes. In progressive muscular dystrophy the most common contracture is that of the calf muscles; the other deformities mentioned above are less frequently seen. It is usually a condition of paresis which upsets the balance of muscular action and leads to contracture of the antagonists, but such disturbance may also arise from hypertrophy of the shortened muscles, as is seen especially in cases with true hypertrophy of the calf muscles.

In accordance with the inborn predisposition to muscular atrophy in some of its forms, it has been sought to ascribe to the same factor certain changes in the skeletal system (Friedreich, Schultze, Eulenburg, Legendre, Jendrássik, Schlippe, Dreyer). Thus, marked atrophy of the bones has been demonstrated in progressive muscular dystrophy. The condition found is a concentric atrophy of the long bones, but without any diminution in length, the epiphysis being well developed. The long bones are therefore much slimmer than normal and the cancellous tissue shows a marked, uniform rarefaction. The vertebræ and the ribs then also suffer in the same way, so that throughout almost the whole skeleton the cancellous bone presents this porous condition. These osseous changes, according to Schlippe, are not of secondary origin. In isolated cases, perhaps, they may be an incidental complication of the muscular dystrophy; in others, however, they may be ascribed with the greatest probability to a common inborn tendency to trophic disturbances that also gives rise to the muscular changes.

As regards the *treatment* of progressive muscular atrophy, gymnastic exercise of the weakened muscles,

carried out with precaution, and also massage may help to some extent. Various writers have attributed improvement in walking to these means (Hoffa). Anything gained by this line of treatment is preferable to the use of supporting sheath splint apparatus. Some temporary benefit may certainly be seen, but the continued wearing of such appliances is followed by an aggravation of the atrophy.

The weakness of the shoulder girdle calls for special treatment when the serratus magnus and the trapezius are involved. For the correction of the winged scapulæ one may employ with some success the bandages recommended for serratus paralysis [10d]. But more good is got from a corset in which the back portion covering the shoulder-blades is supported by a band passing from the front of the axillary support back over the shoulder to the level of the waist at the opposite side.

When one has to deal with a *stationary* case in which the shoulder girdle is specially affected one may give consideration to operative treatment. As the conditions necessary for the transplantation of muscles are lacking, the surgical measures are restricted to the mechanical fixation of the scapula on the thorax. Von Eiselsberg has tried suturing the scapula to the ribs, but without success, and had better results from fixing the shoulder-blades to one another. For the latter purpose he refreshed the inner borders of the scapulæ and sutured them together. The approximation of the clavicle to the first rib in consequence of the drawing back of the shoulders may set up more or less severe signs of compression on the nerves and vessels, for the relief of

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[10d] See p. 65.

which it may be necessary to elongate the clavicles by means of a bayonet-shaped osteotomy. The joining of the shoulder-blades was attended by success in two cases, and, when Ehrhardt examined them three years afterwards, he found that the arms could be abducted and raised almost to the horizontal as compared with the 20° and 30° respectively, which were the previous limits of voluntary elevation.

Contractures, if present, demand a radical treatment. In paresis of the quadriceps, walking may be made again possible if the contracture of the knee is got rid of by remodelling and transformed into a slight over-extension. The power of locomotion is also improved when a talipes equinus or equino-varus is corrected by tenotomy of the tendo Achillis and remodelling.

Muscular dystrophy does not lend itself to operations for the transplantation of tendons or muscles, because the progressive character of the disease may lead to the failure of power in a grafted muscle previously functionating.

(b) DIFFUSE AFFECTIONS OF THE SPINAL CORD, NOT SYSTEMIC.

(1) AFFECTIONS THE RESULT OF DISEASES OF THE VERTEBRÆ.

Myelitis from Compression in Vertebral Caries.

Among the symptoms of *tuberculous spondylitis,* those which point to an implication of the spinal cord or the nerve roots have a serious bearing on prognosis. We designate them concisely as "*cord symptoms and root symptoms.*" The sensory root symptoms have

been referred to when describing the neuralgias, and they consist in more or less violent radiating pains in the area of distribution of the nerves whose sensory roots are involved in the changes taking place in the bones, partly through being compressed and partly through extension of the inflammatory process. The motor aspect of root symptoms is evidenced in exaggeration of the reflexes when the corresponding sensory roots are irritated. A diminution of reflex excitability up to complete loss of the reflex is conceivable if the anterior motor root be directly affected.

The root symptoms may be often the indication of a commencing compression of the cord, or they may be occasionally a sequel of that, or they may also exist without any accompanying manifestations of pressure on the cord.

These root symptoms may take the form of pain at the back of the head, corresponding to the distribution of the occipital nerve and caused by high cervical spondylitis, of girdle-pains of the thorax in dorsal spondylitis, complained of as "pain in the chest"; and we have previously referred to the "belly-ache" occurring in young children suffering from lumbar spondylitis, and also to the sciatica pains on one or both sides arising from the same cause.

Alterations of sensibility may be also observed in the affected nerve region in the guise of hypæsthesia or anæsthesia, frequently preceded by a hyperæsthesia. Œdema and herpes zoster have also been noticed.

The root symptoms are of interest in caries of the lowermost cervical and uppermost dorsal vertebræ when the vertebræ in relation to the cervical enlargement of the cord are affected. Paralyses and signs of irritation

in the region of the brachial plexus may then manifest themselves, owing to the damage done to the corresponding roots where they emerge from the spinal canal. If the eighth cervical and first dorsal roots are implicated, there is pain and disturbance of sensibility in the ulnar region along with paralysis and atrophy of the small muscles of the hand, and there is further a peculiar affection of the eye. Spastic dilatation or paralytic contraction of the pupil results from the irritation or the paralysis of the cervical sympathetic fibres passing to the pupil [dilator pupillæ] through the roots of the cervical part of the cord. At the same time as the pupillary contraction one may observe a narrowing of the palpebral fissure and a retraction of the globe. When the fifth and sixth cervical roots are involved one finds, according to Oppenheim, an atrophic paralysis of the deltoid, biceps, brachialis anticus and supinator longus, accompanied by anæsthesia of the skin over the deltoid and on the outer side of the arm and forearm.

The paralytic manifestations which are set up by damage done to the spinal cord itself, may depend on a variety of pathological circumstances. Wullstein classifies them as ischæmic paralyses, deviation paralyses, also paralyses resulting from compression by pathological products, and finally those produced by an actual tuberculous myelitis.

This last cause of paralysis is exceptionally rare and makes its appearance only in the terminal stages of spondylitis. The prognosis in such cases is absolutely hopeless, as a restitution of the substance of the spinal cord is no longer to be expected when once that has been transformed into tuberculous tissue.

Ischæmic paralysis is also somewhat rare. A classical instance of it was observed by Wieting. In this case (a boy, aged 11) paralysis with œdema of the lower extremities set in suddenly in the second year of the disease. The *post-mortem* examination revealed tuberculosis of almost all the vertebral bodies, and the aorta was found bent nearly to a right-angle. A thrombus projected from the tenth intercostal artery into the lumen of the aorta. The consequence had been an interference with the blood supply to the lower parts of the body. The ischæmia was thus due to the flexion and the thrombus formation in the aorta and had caused the paresis of the extremities, as was proved by the examination of the spinal cord.

Compression of the cord may be produced either by narrowing of the spinal canal as in deviation paralysis, or by the pressure of inflammatory products. The deviation paralyses are induced by those alterations in their relative positions which the vertebræ may undergo when altered and softened by the carious inflammation. If they only slowly encroach upon the spinal canal there may be no paralysis, since the cord is marvellously resistant to the effects of a *gradual* compression. But severe paralysis will probably ensue if the canal is suddenly narrowed, as may be the result of even a trivial injury to the carious bones crushing them together. In rare cases a tuberculous sequestrum penetrating the spinal canal may set up the signs of compression of the cord.

It is much more frequently the case that the inflammatory products of the diseased bones are the cause of compression paralysis. Thus an abscess may encroach on the canal and press on the cord, or granu-

lation tissue may act in the same way. It is not necessary for the tuberculous granuloma to have first of all attacked the dura mater, as a voluminous mass of tissue lying between the bones and the membranes of the cord is sufficient to cause compression. In advanced cases the outer layers of the dura become infiltrated as well, and a definite external tuberculous pachymeningitis is the result.

It may be further remarked at this point that the symptoms of compression of the cord and of irritation of the roots may be produced by *tumours of the vertebræ* similarly as by tuberculous spondylitis. A correct diagnosis thereof is often difficult, especially if the condition is one of a primary malignant tumour of the vertebra. A case recorded by Reiss may be cited from the literature, in which a primary vertebral sarcoma was only demonstrated at the autopsy. In another case it was left for the *post-mortem* to prove that, instead of tuberculous spondylitis with compression myelitis, there was present an osteoma of the spine that had started in the spinous process of the tenth dorsal vertebra and grown so as to compress the cord (Hermes). Similar results may follow on bony outgrowths such as occur in the bodies or processes of the vertebræ in tertiary syphilis. Similarly may gummata projecting from the bone cause compression. Further difficulties in differential diagnosis are provided by the consideration of the possible occurrence of *tumours* originating in the *cord* itself, in the *meninges* or in the *nerve roots*, which may produce the most manifold root and cord symptoms. The removal of such growths in favourable cases has been attended by very good results.

Compression of the spinal cord leads, in the first place, to œdema, as the result of pressure on the veins in the dura and on the epidural venous channels, with a consequent lymphatic congestion, the arterial blood supply being unaffected. It has been realized since the searching experimental investigations of Kahler and of Schmaus that the cord is unusually sensitive to any disturbances in its lymphatic system, and that these rapidly evoke paralytic manifestations. An œdema of this nature may exist for a long time without softening of the cord or its sequelæ of degeneration and sclerosis ensuing. So long as the last-mentioned incurable lesions have not set in, the treatment of the paralysis may have the best results.

The type of the paralysis corresponds to the situation of the segment of the cord subjected to compression. With a compression-myelitis high up in the cervical region there is found *spastic* paresis of *all* the extremities. With caries of the lower cervical vertebræ, when the compression takes place in the region of the cervical enlargement, there is found in addition to spastic paralysis of the lower extremities a flaccid paralysis accompanied by atrophy in the upper limbs. If the caries affects the cord lower down in the dorsal region, then the arms escape while the legs show a spastic paralysis. Lower down still, at the junction of the dorsal and lumbar regions, if the lumbar enlargement of the cord is compressed there is flaccid paralysis of the legs. It would take us too far to describe fully here the alterations in sensibility and motor function which may be caused, or to discuss the state of the reflexes and the condition of the bladder and rectum. All such disturbances depend in their variety and character upon

the level of the affected segment of the cord and upon the severity of the lesion. When the sacrum or the sacro-iliac joint is attacked by tubercle, the development of an abscess or of a caseous pachymeningitis, or the two together, may cause pressure on the cauda equina, or may involve it in the disease (Hahn, M. Bartels). In such a case there is a characteristic symptom-complex, which is specially manifested in paralysis affecting the bladder, rectum, and genital organs, and in a zone of anæsthesia with the so-called "riding-breeches" distribution.

With regard to the relationship between the site of the spinal caries and the paralysis, the statistics of Bouvier show that there is no paralysis in one half of the cases of cervical disease, nor in seven-eighths of the cases of lumbar disease, whereas in the dorsal region spinal caries is associated with paralysis in more than one half of all the cases. W. Neumann has also laid stress on the fact that dorsal caries takes first place in this respect, and that 80 per cent. of all paralyses due to spondylitis have their origin in the dorsal region.

The causal connection between paralysis and vertebral caries is not liable to be misapprehended if the symptoms of the caries are distinct and not obscured by other diseases of the nervous system. The neuralgic pains, the stiff attitude of the body, the spastic rigidity of the part of the spinal column affected, the hump-back, if present, the tenderness on pressure or movement at the site of the bone disease, these all are symptoms of an existing spinal caries which cannot fail to be recognized. In adults, however, there may occasionally be no hump, even long after caries has been in existence. Spondylitis may be present and lead to

abscess formation which causes compression of the cord, but the destruction of the vertebræ may be only superficial and so no gibbosity develops. The same may be the case when the tubercle attacks the vertebral arches. A commencing angular curvature at the junction of the cervical and dorsal regions may be overlooked, being mistaken for the normal prominence presented by the seventh cervical or first dorsal vertebra. In the lumbar region again, the lordotic posture normally existing there may obscure the early stages of a gibbous formation. In some particular cases while the objective signs of spondylitis may not be distinct, there may be a very obvious hysterical condition. Should the subjective symptoms be attributed to the hysteria as the sole cause, the diagnostic error may have the gravest consequences (A. Saxl). In difficult cases such as these, skiagraphy is still always capable of clearing up the obscurity.

The *prognosis* as to the paralytic features in vertebral caries is dependent on the state of affairs in regard to the spinal cord. It is absolutely unfavourable if, as in the case mentioned of Wieting, a thrombosis of the aorta is the cause of an ischæmic paralysis. Again, a sudden crushing of the cord as the result of a fracture-dislocation of diseased and softened vertebræ will have a fatal issue, as will likewise a tuberculous infiltration of the cord itself. On the other hand, a more hopeful prognosis may be given in ischæmic paralyses due simply to bending of the aorta, also in deviation paralyses of the cord of slow development, and those due to the pressure of inflammatory products from diseased bone. The prognosis in children is more favourable than in adults in respect of the paralysis, as

also of the causal affection itself in most cases. As shown by the statistics of Dollinger, Little, Lorenz, Lovett, Reinert, Vulpius, and Hoffa, recovery from paralysis took place in 100 out of 160 cases. The duration of this condition is very variable, covering a period of months or years. We have observed in one case the disappearance of a complete paralysis of the legs after two years of treatment.

The *treatment* of a pressure paralysis in spondylitis has to aim at the release of the spinal cord from constriction. It is not perhaps wholly necessary that the spinal canal should regain its normal dimensions, for the vessels of the cord have a considerable capacity for accommodating themselves to the narrowing of the canal, and with the restoration of the normal circulation the reparatory processes in the cord will be initiated. The requirements here set out go hand in hand with the mechanical treatment of the spondylitis. The first task is to relieve the sick child of pain, and this is best secured by the fixation of the spinal column so that the painful movements between the diseased vertebræ are put an end to. For this purpose one may provisionally bandage round the trunk with ordinary bandages or with towels. In order to improve the state of the circulation in the constricted part of the spinal cord, it is necessary to take the burden and strain off the surrounding bony structures which are cariously softened. This requirement is met by means of *extension* or *reclination* [11] of the spinal column. The

[11] The term reclination of the spinal column embodies the idea of a backward curving of the spine *as a whole*, that is to say, a tendency toward a general lordosis, the effect of which, of course, is an artificial increase of the normal lordosis of the cervical and lumbar regions and a diminution of the normal

latter method attains the object of taking all strain off the bodies of the vertebræ in a simpler and more direct fashion than does extension. If we picture to ourselves the mode of action of extension on the spinal column, it is at once apparent that the first effect of traction is directed to flattening out the normal antero-posterior curves of the spinal column. This results in a separation of the vertebral bodies from each other in the kyphotic dorsal region, but in the lordotic segments of the spine, in the cervical and lumbar regions, the effect of extension on the lordosis is first of all to press the bodies of the vertebræ together, and only when the extension is more powerful is this pressure relieved. As it is difficult to apply sufficiently powerful traction to the trunk, in its middle and lower portions especially, the method of reclination recommends itself at once as the more effective and simpler plan for dealing with these segments. In the case of the cervical part of the spine, the uncomfortable position of the head in reclination is a disadvantage, and extension must be given the preference in cervical caries, the more so as it can be applied here with full effect without difficulty. Both extension and reclination relieve the diseased area from pressure more efficiently than does the simple adoption of the horizontal posture.

The conditions above postulated of fixation, exten-

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dorsal kyphosis. The result of this posture is the relief of pressure in general, but especially between the anterior portions (the bodies) of the vertebræ.

In the cervical and upper dorsal regions reclination is apt to produce an uncomfortable position for the head, but, fortunately, extension of this portion can be readily effected. For the lower dorsal and lumbar regions, in which sufficient extension is obtained with great difficulty, the position of reclination is admirably suited.—Translator.

sion and reclination of the spinal column are fulfilled most simply in treatment by means of Lorenz's plaster-of-Paris bed [12]. When the disease is situated in the

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[12] The plaster-of-Paris bed was devised by Lorenz as a simpler and cheaper, and also as a better means of treating spinal caries than that furnished by the somewhat elaborate appliances previously in use for treatment on similar principles. It is made as follows: The patient is laid prone on a table. A sheet of splint-wool is spread over his back, reaching from the crown of the head to the gluteal folds, and this is covered by a layer of calico. If there is a sharp angular curvature the prominence is protected with extra wool padding. Plaster bandages (best made of gauze) are then systematically applied to cover the whole of this area. They are laid on first in the vertical direction, radiating from the head, and also laterally, and when a certain thickness is attained cross turns are applied. To save time, vertical strips may be made up on the table by unrolling a bandage in turns to and fro, and the thick sheet thus made is then moulded in position on the patient's back. When completed, the plaster bed is lifted off the patient. The edges are then trimmed with a knife or strong scissors, cut out to fit the arms, and finally smoothed and rounded and bound by a starch bandage. The whole bed can now be dried in an oven and varnished.

When ready for use, it is thoroughly well lined with wadding covered with a sheet. If desired, the bed may be handed over to an instrument-maker as a model to be made up in a more finished style, upholstered with horse-hair covered with buckskin. The bed is placed on the patient's back and secured by bandaging, and the patient can then be fully dressed. He can easily be taken out into the fresh air with full security when lying in this bed, an advantage which is a special feature of this method of treatment.

To obtain the position of *reclination* when applying the plaster, the patient is laid face down on the table and small firm cushions are placed under the forehead, the clavicular region and the thighs. The spine then gradually sinks down between the cushions and the position of the one under the thighs is adjusted so as to give the amount of lordosis considered proper. The feelings of the patient are an important guide in this respect.

In the application of the *extension* plaster bed the patient is placed so that the back of the head is in a straight line with the rest of the back. He should, therefore, be laid on a flat, level cushion extending from the clavicles to the thighs, while the forehead rests on a small, low cushion.—Translator.

middle portions of the spine, reclination, as stated, is the more effective and simpler plan. The plaster bed is applied accordingly with the patient lying on his face and supported on cushions so arranged as to produce a suitable lordosis of the trunk. It should be remarked here that children submit well, as a rule, to a considerable lordosis, but in adults it may cause unbearable pain and should be avoided. The plaster bed reaches from the head down to the gluteal folds and extends also over the sides of the trunk, so that the patient, when bandaged up in the previously padded plaster bed, is in a state both of *reclination* and *fixation*.

The position of reclination is less well adapted for disease of the upper portions of the spine, of the upper dorsal region and above. In such case one employs with advantage the *plaster bed with extension* (fig. 13) [12a]. It is applied to the patient lying horizontally, face downward. At the top of the bed is attached an angled iron bracket (jury-mast) which carries a cross-piece opposite about the middle of the parietal bones. The head is drawn up toward this cross-bar by a sling supporting the chin and the occiput (Glisson's sling). As before, the child is bandaged in position in the padded bed, and this is set up slanting with the head end raised, so that the weight of the body acts as counter-extension. Since the trunk is consequently stretched, the lower margin of the bed should be made to project beyond the gluteal folds. For the purpose of "changing the bed" the patient is laid down on his face, the enveloping bandage removed and the bed

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[12a] See p. 53.

simply lifted off the patient. The skin of his back is then attended to, and the bed padding and the sheet covering it adjusted or renewed. The bed is then once more placed in position and the patient laid on his back. For purposes of defæcation the invalid is placed upright along with his bed, unless one has preferred the plan of cutting a piece out of the plaster trough opposite the anus, so as to permit of defæcation in the recumbent posture.

In some special circumstances, as, for instance, if contractures are forming or painful clonic spasms are present, it may be thought desirable to fix the legs as well in a suitable trough splint. In such a case the reclination plaster bed, with or without extension, may be constructed so as to include within it the legs, which should be slightly separated from one another.

The patient remains in the fixed position of reclination or extension until the paralysis has wholly disappeared. Thereafter he may resume the wearing of a corset suitable for the treatment of spondylitis and go about in it (figs. 29 to 31). As has been mentioned, the treatment by means of the plaster bed often must be continued for a long time before success is attained. The manner in which this comes to pass is evident in the case of deviation paralysis, inasmuch as the narrowing of the spinal canal is corrected, and similarly in ischæmic paralysis due to kinking of the aorta, as that vessel can once again follow a more direct course. But even the pressure effects of inflammatory granulation tissue and abscesses may be diminished if more room is allowed them, as a result of the bony structures, previously crushed together, being again separated.

When treatment by reclination and extension has

been persevered with for a long period, but without result, and serious complications are threatening on account of paralysis of the bladder function, it may perhaps be well to consider forcible correction of the angular curvature by Calot's method, which has now and then shown favourable results in severe paralysis. That is the only occasion when there is an indication

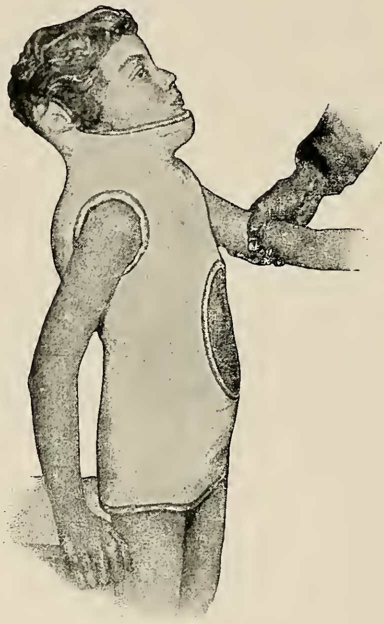

FIG. 29.
Plaster bandage to secure extension. (After Calot.)

for this method of treatment, which when first introduced played a prominent *rôle* in the management of spondylitis, but only for a short time. Success is most likely to be obtained by this method, which is itself a source of danger, in the case of an osseous encroachment on the spinal canal causing paralysis, and it is

also possible that benefit may result from the reduction of an angular curvature by giving more room to an abscess which had been setting up compressive symptoms.

Attention has been directed to the possibilities of *operation* for the cure of paralysis since Macewen, in

FIG. 30.
Corset fitted with a support to the chin and occiput to secure extension.

1886, adopted with happy result the plan of resecting the vertebral arches (*laminectomy*) in order to free the spinal cord from the constricting tissue present. Trendelenburg also strongly advocated this operation, by means of which he relieved a paralysis of seventeen years' duration. Generally speaking, however, the

results of this procedure were not satisfactory, both on account of the high mortality and also because of the relapses after temporary improvement of the paralysis. The operation would be principally indicated in cases of tuberculous disease attacking the vertebral arches, and when there is pachymeningitis with new tissue formation pressing on the spinal cord.

FIG. 31.
Plaster-of-Paris corset applied to produce reclination.

Sometimes the performance of a laminectomy has thrown no light on the cause of the paralysis. Ménard (1894) has suggested that in such cases a prevertebral abscess is responsible for the paralysis. It is well recognized that frequently the evacuation of a spinal abscess may lead to recovery from a paralysis. Thus Joachimsthal has described how, in the case of a boy

aged 9 with dorsal spondylitis and spastic paralysis of the lower limbs of six months' duration, the paralysis rapidly disappeared after the opening of an abscess under the sternomastoid.

According to the statistics of Lannelongue and Bouvier, abscess formation occurs in 96 per cent. of the cases of spondylitis, and further, the spondylitis is in the dorsal region in 84 per cent. of the cases complicated with paralysis. The causal connection between dorsal spondylitis with paralysis and the existence of an abscess is to be explained by the restriction here offered to any increase in size. While an abscess may extend somewhat freely in the cervical or lumbar regions, a prevertebral abscess often encounters great resistance in the dorsal region. This is shown also by the great tension in these abscesses noted by Lannelongue. When the body of a vertebra has become wholly destroyed and transformed into an abscess, the contents under high pressure cause the periosteum to bulge into the spinal canal and thus the cord is compressed, as Ménard has pointed out. The evacuation of the abscess is therefore indicated in such cases, and this has been done with success by Ménard (1894) by means of the operation of *costotransversectomy,* which consists in resection of the transverse process of the vertebra and a portion of rib, so as to open up a track to the abscess. The good results of this operation have been confirmed by Wassiliew, Goldmann, and W. Neumann.

To be able to demonstrate with certainty the presence of an abscess one must seek the aid of skiagraphy, which may also be able to give some more exact information as to the topography of the abscess, such

as determining whether it extends on one or on both sides of the spinal column.

The indication for operation in spondylitis with paralysis is not so assured, when one reflects that sometimes after a lengthy period a paralysis may yet pass off under conservative treatment. Gibney has observed a successful issue after no less than ten years. The social conditions of the patient, of course, demand consideration in respect of this question. Oppenheim puts forward the following indications for operative interference: (1) in the case, on the whole very rare, of caries of the vertebral arches, should this not get well under conservative treatment (Péan); (2) if a superficial abscess, when incised, is found to be in close connection with the focus of disease in the body of a vertebra; (3) if paralysis persists after a lengthy illness, in spite of an apparent cure of the spondylitis, and the trial of extension, &c. (Trendelenburg).

It is necessary to emphasize the fact that a recurrence of the paralysis may be sometimes observed after conservative as well as after operative treatment.

With regard to lesions affecting the cauda equina, the measures to be considered are the conservative treatment by means of a plaster-of-Paris bed, combined with extension for the legs, or the operative treatment of the diseased bone, which is favoured by Bardenheuer.

The *contractures* which sometimes develop during the paralytic state require individual special treatment. The commonest varieties are flexion-contractures of the hip (not to be confused with the contractures due to inflammation of the psoas or psoas abscess), flexion-contractures of the knee and pointing of the foot. Since the contractures are due to cellular changes in

the shortened muscles, they are treated by tenotomy of the retracted tendons and soft parts and subsequent remodelling of the limbs. In the more severe cases at the hip subtrochanteric osteotomy of the femur may be found necessary.

Spinal Symptoms in Typhoid Spondylitis.

Though of less importance than the foregoing, the spinal symptoms which may appear in the course of *typhoid spondylitis* in any case deserve mention. Typhoid spondylitis is one of the rarer late complications of typhoid fever and usually begins in the afebrile stage of convalescence by causing a renewed rise of temperature and pain in the lumbar region. The pain radiates toward the lower part of the abdomen and to the thighs. There is next spastic fixation of the portion of the spinal column affected, usually the *lumbar segment*. Tenderness to pressure and sometimes also a swelling are observed in this region. In many cases a gibbosity may be found to develop, but only if the disease has lasted a considerable time. This feature occurs when the presence of numerous collections of bacilli gives rise to the formation of small abscesses in the anterior parts of the vertebræ which have been attacked. As the bone in consequence becomes softened, the weight of the body tends to crush the vertebræ together, and thus the hump begins to form [13].

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[13] A case of spondylitis occurring in *paratyphoid* fever has been described by McCrae (*American Journal of the Medical Sciences*, December, 1906), in which skiagraphy revealed a deposit of new bone between the fourth and fifth lumbar vertebræ on both sides. He also describes a case of typhoid spondylitis with slight projection of the second, third and fourth lumbar vertebræ. A skiagram showed a bony deposit between the second and third vertebræ on one side.—Translator.

Spinal symptoms are of frequent occurrence and are manifested in signs of irritation or paralysis of the lower extremities, and in disturbance of function in the bladder and rectum. The cause is to be found in the inflammatory œdema which extends around the diseased vertebræ and so damages the cord or nerve roots.

An injury or the putting of too great strain on the spinal column during convalescence from the fever will conduce to typhoid spondylitis being set up. The disease lasts for several months before recovery, but this can always be relied upon to take place, and there is no special tendency to the occurrence of suppuration.

The *treatment* of typhoid spondylitis in the acute stage consists in relieving the patient of pain by laying him in a well-padded plaster-of-Paris bed. Wullstein recommends that this should be applied with the patient in the fullest possible position of reclination, so that hyperextension of the bodies of the vertebræ may be attained by the lordosis of the spinal column, by which means the pain and the other acute symptoms are favourably influenced. If, however, the patient cannot endure this lordotic posture of the trunk, one must be satisfied with applying the plaster bed with no further lordosis than the patient can bear in comfort. At a later date, when the patient has so far recovered, he is provided with a supporting corset, made up from a model, to be worn for several months.

Injuries of the Cord from Dislocations and Fractures of the Spinal Column.

While *dislocations* pure and simple are almost only to be observed in the cervical region, *fractures* on the other hand may occur at any level, but are principally

found in the region of the lower cervical vertebræ and at the junction of the dorsal and lumbar portions. The dislocation *in toto* of a vertebra may damage the spinal cord and its roots, and so may also a fracture, but one cannot straightway diagnose conversely from the signs of a transverse lesion that there is dislocation or fracture of the corresponding vertebra, since experience has taught us that severe or even fatal injuries of the cord are also possible from a *distortion* or twist given to the spinal column. On the other hand, in many cases of fractures and dislocations there may be a complete absence of spinal cord symptoms.

One endeavours by reduction of the dislocated vertebra or by careful attempts at reposition of the broken fragments to relieve the cord from pressure and then to make sure of the result obtained by putting the patient in a suitable posture. A correct posture is also of the greatest importance, should the attempts at reposition have failed, for any further displacement of the vertebral fragments may transform what was originally a slight into an irreparable damage to the cord. On that account, too, the preliminary examination and the transportation of the patient must be undertaken with the greatest caution.

The fundamental principles of *treatment* are *fixation* and *relief from pressure*. These conditions can be secured only with the patient in the horizontal position, in similar manner to that described in connection with compression-myelitis due to spinal caries. Fixation is best obtained by the plaster bed, which is furnished with an extension fitting for the head when the cervical portion of the cord is injured. If the fracture is situated in the middle or lower part of the dorsal or

in the lumbar region, a reclination plaster bed is made up. The advantage gained by the position of reclination is due to the lordosis produced tending to separate the fractured vertebræ, while at the same time the usually intact posterior common ligament is made tense and draws into place the vertebral fragments which may project into the spinal canal. A traumatic humpback, too, may disappear spontaneously when the trunk is placed in the position of reclination. The plaster bed must be thoroughly well padded, and the risk of pressure sores is to be anticipated by careful inspection, and giving attention to the parts specially threatened, such as the sacrum, heels, &c. To facilitate the examination or cleansing of the back and buttocks the patient is turned on his face, secured as he is in his plaster bed by binders. One next arranges cushions beneath his body so as to maintain the reclination of the trunk, and may then proceed to remove the binders and lift off the plaster bed. These procedures are reversed when the patient is to be placed on his back again. Affections of the bladder and rectum, if present, must be treated on the usually accepted principles. Only when the paralytic manifestations have wholly gone is the patient to be allowed to go about wearing a plaster-of-Paris corset, applied in the position of reclination and fitted, if need be, with an extension support for the chin and back of the head. After several months have thus passed, and if progress is favourable, the patient may be permitted to wear a removable corset. But this is to be used for a full year, as otherwise, if it is discarded too soon, a hump may subsequently develop, or if one is already present, it may become more marked.

If a *total* transverse lesion of the cord has been produced, there is no justification for any *operative* treatment of the paralysis, such as removal of the transverse processes and vertebral arches (laminectomy) and removal of compressing fragments. Operation in the early stage also is equally improper, for, as Oppenheim states, it cannot be decided till some time after the injury how far the spinal symptoms are to be attributed respectively to compression, to hæmorrhage in the substance of the cord, or to simple concussion in particular. If the interruption to conduction is but *partial*, and should the paralytic signs not improve under conservative treatment, or should they get worse, one may then more readily decide upon operation, especially if the vertebral arches are fractured. The same considerations hold good for irreducible dislocations.

Cord and Root Symptoms of Compression in Arthritis Deformans and Chronic Inflammation with Ankylosis of the Spinal Column.

Experience has shown that damage to the cord and its nerves is principally caused by tuberculous disease of the spine. Apart from syphilitic conditions and tumours of the spine, there remain almost only those cases in which chronic inflammatory, non-tuberculous, proliferative processes in the vertebræ furnish the exciting cause of such cord and root lesions. Neuralgia may be felt in the arms, the chest, the abdomen or the legs if the intervertebral foramina in the part of the spine so affected become narrowed. Very rarely there ensues a *spastic* paralysis in consequence of compression of the cord. Should this be the case, however,

account must be taken of possible tuberculous disease in making the differential diagnosis. Thus Simon observed the occurrence of compression-myelitis in the course of a chronic inflammation with ankylosis of the spinal column, and the cause of this complication was an acute caries of the second and third dorsal vertebræ.

Atrophic paralyses in the muscles of the limbs are more commonly found and are due to compression by new bone of the motor root fibres.

While the cord and nerve symptoms in the cases of chronic stiffening of the spinal column present no outstanding features of interest, the nature of the affection of the spine itself has been subjected to most searching attention. The early descriptions of stiffening of the spinal column submitted by Wenzel (1824) were extended by Braun (1875), who published clinical and anatomical contributions to the knowledge regarding spondylitis deformans. But investigations only attracted more notice when Bechterew, Strümpell, and Pièrre Marie put forward particular types of stiffening of the spinal column.

Bechterew described a variety of the condition in which either the whole spinal column becomes rigid in a kyphotic position, or else only the dorsal region is so affected; the disease process remains localized there or may spread downward, accompanied by pain. Further characteristics, according to Bechterew, are the immunity from the disease of the large joints of the extremities next to the spine, and also the occurrence of root symptoms, evidenced partly by atrophic pareses of the muscles of the trunk or the extremities, and partly by irritative phenomena, such as paræsthesia,

hyperæsthesia and pain. Ætiological factors are to be found in syphilis, traumatism, and heredity.

A different complex of symptoms was set forth by Strümpell and Pierre Marie. The spinal column becomes stiffened, and there is little or no pain. The disease commences usually in the lower end of the spinal column and extends upward. It is not restricted to the spine, but attacks also the large joints of the body, or as Marie describes them, the root-joints of the limbs ("*spondylose rhizomélique*"). When the lumbar region is affected, the spine loses its normal lordosis there, and as a whole becomes extended. When the cervical region is involved it develops a kyphosis. The process usually starts in early life and root symptoms do not occur. Chills and infective diseases, especially gonorrhœa, are of significance as causal conditions.

The respiratory immobility of the thorax, which is a feature, with at the same time increased abdominal action, is attributed in the Bechterew cases to atrophy and paresis of the respiratory musculature, and in the Strümpell-Marie cases to rigidity of the costovertebral articulations.

More exact study of the special aspects of the disease has shown, however, that the differentiation of stiffness of the vertebral column into these two clinical types cannot be maintained. As Oppenheim has pointed out, both clinical and *post-mortem* investigations have proved that the group features of the two types are not at all sharply separated. Many a peculiarity ascribed to the one type may be lacking in it and yet well marked in the other type. This is the case as regards the involvement of the large joints (Anschütz, Magnus-

Levy), the direction in which the disease progresses, the deformation of the spinal column, as also the significance of the ætiological factors mentioned.

An attempt has therefore been made by various observers to classify the chronic stiffening of the spine on the basis of pathological and skiagraphic findings. According to E. Fraenkel, Simmonds, Schlayer, and others, there occur two different processes, namely, *spondylitis deformans* and *chronic ankylosing arthritis*.

In **spondylitis deformans** the disease attacks, usually in later life, at first the intervertebral discs, then there ensues a deformation of the bodies of the vertebræ, consisting in the growth of exostoses on them, and this leads to the bony union of the vertebral bodies. The small joints of the vertebræ are attacked only individually or in particular localities.

In **chronic ankylosing spondylarthritis** the affection commences usually in early life by attacking the small joints of the vertebræ, spreading at the same time over a considerable extent of the spinal column with synostosis as a consequence. Usually the ligaments also become ossified, while the bodies of the vertebræ suffer no material alteration. The formation of exostoses is observed but rarely.

The demonstration of osseous bridges between the individual vertebræ is alone not sufficient basis for a definite diagnosis, according to Fraenkel, since this feature may be present in either spondylitis deformans or chronic ankylosing spondylarthritis. If skiagraphic examination shows that the vertebral bodies are unaffected, that is definite proof of the latter condition; if they show some deformity, that is evidence of the former condition. In ankylosing spondylarthritis the liga-

ments are at first unaffected. The primary condition is ulceration of the cartilages leading to fusion of the articular processes, which at first is a fibrous union, but later becomes osseous, and the articulations also between the ribs and the vertebræ may undergo the same process of ankylosis. Fraenkel regards this as an *arthrogenous* affection of the vertebral and costo-vertebral articulations, analogous to Ziegler's chronic ankylopoietic arthritis. Whereas the rigidity of the spinal column in spondylitis deformans does not usually extend over so large a range as in the other type of disease, often involving only the lower dorsal and lumbar regions, in the case of ankylosing spondylarthritis it is usual for the whole spinal column to become affected little by little. In the latter, the rigidity is brought about by the fusing together of the ulcerated cartilaginous surfaces of the articular processes and the costo-vertebral joints, but in spondylitis deformans it is due to the formation of exostoses, which spring up around these smaller articulations of the vertebræ and thus anchor them together. In both conditions there may develop a marked *osteoporosis*, as Schlayer points out.

The pathological and skiagraphic evidence would then seem to mark out spondylitis deformans as an *osteogenic* process, and ankylosing spondylarthritis, on the other hand, as *arthrogenic*. It should be mentioned here that in the latter disease the skiagraphic examinations are often for a long time negative, while in deformative spondylitis marked alterations in the vertebræ may be discoverable at a comparatively early stage.

The attitude of those patients suffering from spinal

rigidity is quite characteristic. If the whole column is affected we then see a general kyphosis of the spine, which is especially prominent in the upper dorsal region (fig. 32). The patient's head is consequently thrust downward and forward. One observes transverse fur-

FIG. 32.

rowing on the front of the abdomen as evidence of the shortening of the long axis of the trunk.

When the patient wishes to look forward or up, he can only do so by bending his knees so as to tilt his body sufficiently far back. If the forward projection of

the trunk is somewhat more exaggerated, the patient finds it necessary to keep his knees or even his hips flexed in order to preserve his balance and avoid tumbling forward.

As far as recovery is concerned, the *prognosis* is unfavourable in chronic stiffness of the spine, nevertheless an arrest of the disease process has been observed at all stages. The state of affairs is more satisfactory in some isolated cases, which, however, are not true examples of this spinal rigidity, but only resemble the condition, being in fact due to a *muscular* fixation of the spinal column induced by chronic rheumatism of the muscles of the back. Such cases were first brought under notice by Oppenheim and Cassirer and we have also observed a similar one. The principal dangers threatened are of lung complications, which are readily set up on account of the respiratory inactivity of the thorax. Pulmonary tuberculosis and pneumonia are the most likely to occur.

As *therapeutic measures* the iodides and salicylates, and especially salol, are recognized as internal remedies, and in addition massage and baths should be employed. Oppenheim recommends natural sulphur baths, and has also found artificially prepared sulphur baths to be beneficial. A course of massage is of particular advantage in the so-called pseudospondylitis, due to chronic muscular rheumatism of the back. In the more aggravated cases one may order a supporting corset, which should help to relieve the pain.

There still remain for mention the attempts which have been made at forcible correction of the deformity of the spine. So far this procedure has been tried only in occasional cases, and has proved itself to be attended

by some risk. If an osteoporotic condition of the bones exists, then the application of the very slightest force may cause some degree of fracture of the spinal column and be followed by serious effects on the cord. Thus Lorenz, on attempting with the greatest care the correction of the lumbar spine, met with the occurrence of a paralysis of the lower limbs as well as of the bladder and rectum, which persisted for a long time. In spite of the application of any undue force being avoided, there ensued without doubt an injury in some form to the spinal column or cord in this unfortunate case. As the most likely explanation, there may have been some trivial damage, such as the fracture of an articular process, which gave rise to hæmorrhage into the spinal canal, as a result of which the cord was subjected to pressure leading to interruption in its conductivity. The spontaneous recovery from the paralysis supports this theory. In a case of Wullstein, the onset of pulmonary complications necessitated the abandonment of treatment by forcible correction, which had been begun.

Symptoms of Compression of the Cord in Skoliosis.

Compression of the cord, with consequent paralysis, is one of the rarest complications that occur in skoliosis. Leyden mentions a case he had observed himself in which a marked skoliosis was associated with weakness of the lower extremities, and also a case of Bampfield presenting paraplegia and bladder trouble. Hoffa treated a girl aged 18 with severe skoliosis, which had developed within a few months, due probably to late rickets. In this patient there was almost complete paresis of the right leg. We have also observed

isolated cases of very marked rachitic skoliosis appearing at the end of the second and the commencement of the third decade of life, in which spastic paresis of the lower limbs developed. In a boy aged 10, suffering from a high dorsal skoliosis presenting a sharp curve, there occurred complete spastic paralysis of the lower extremities with contractures of the hips, knees, and ankles. The hump formed by the distortion of the deformed vertebræ and ribs was about the size of the palm of the hand and felt like a large prominent bony tumour. The whole aspect of the condition, in particular the almost complete absence of any compensatory curving of the spinal column, made it seem as if the skoliosis were congenital. The child had previously been examined when five years old on account of his parents having noticed a curvature of the spine. Unfortunately the skiagram furnished no explanation as to the immediate cause of the compression. Disturbances of the bladder and rectum were absent in this case of ours, as in a similar one referred to by Bachmann, in which there was present a hump on the ribs situated opposite the middle of the dorsal region and giving the impression of a flat bony tumour, the size of the palm of the hand.

As regards *differential diagnosis,* it is of importance to exclude tuberculous spondylitis as a cause of the paralysis, and this is especially difficult when spondylitis and skoliosis are simultaneously present. Again, one occasionally sees patients with skoliosis and spastic paresis of the limbs, which conditions are found on thorough examination of the nervous system to be due to spinal gliosis or syringomyelia. We have observed a similar clinical picture in a patient with severe

rachitic skoliosis, suffering at the same time from disseminated sclerosis.

Treatment of the paralytic manifestations actually due to skoliosis is carried out on the same lines as for compression-myelitis due to spinal caries. The patient is laid in a plaster bed designed for treatment by extension or reclination. If contractures in the lower limbs are setting in, one endeavours to overcome them either by the use of extension to the legs, or by the use of an appropriate trough splint. If unsuccessful for any reason, as, for instance, on account of the painful feeling of tension induced in the legs, one will correct the resultant contractures later on by means of tenotomy and myotomy and subsequent modelling redressment.

(2) PRIMARY DIFFUSE AFFECTIONS OF THE SPINAL CORD.

Spinal Gliosis and Syringomyelia.

It has been mentioned previously that caries high up in the spine may give rise to atrophic paralysis of the upper and spastic paraparesis of the lower limbs, and likewise that skoliosis in rare cases may be complicated by spastic paresis of the lower extremities. A similar combination of symptoms is present in those cases of syringomyelia in which *skoliosis* is found *coincidently* with the symptoms of the kind mentioned, namely, atrophy of the muscles in the upper extremities and spastic paresis in the lower. The relationship between the condition of the spine and the rest of the symptom-complex is, of course, fundamentally different. In the former cases we find the spinal cord secondarily affected by some trouble in the vertebral column, while in

syringomyelia, on the other hand, the disease of the cord brings about trophic disturbance which is exemplified in curvature of the spine among other alterations of the bones and soft parts.

The skoliosis which develops in syringomyelia has been closely investigated by Bernhardt, Schlesinger and Borchard in particular. Bernhardt computes the frequency of this neurogenic skoliosis at 25 per cent. of the cases, with which Schlesinger is in agreement. The exceedingly high figure of these authors may, perhaps, find an explanation in the skoliotic conditions occurring in syringomyelia being not wholly caused by this disease. It is, however, likely that a curvature previously existing in the spine undergoes a considerable aggravation when the bony structure of the vertebræ becomes altered by syringomyelia. This alteration consists mainly in a rarefaction of the osseous tissue and a diminution in the amount of lime salts present, whereby the spinal column readily suffers from any deformative influences. Borchard failed to find any gross changes in the vertebræ, any disease in their articulations, or any new bony outgrowths from them, nor did he find any ossification of the ligaments or in the muscles of the spinal column, such as are usually present in the diseases of bones and joints elsewhere due to syringomyelia. Since, however, it is usual for an affection of the spine to be combined with affections of other bones and joints, it will require further investigation to clear up this apparently irregular manifestation of the syringomyelic lesions.

Skoliosis in syringomyelia begins, as a rule, in the vertebræ of the lower cervical and upper dorsal regions and may thence spread further. If it remains localized

at this site, then compensatory curvatures are developed throughout the remainder of the spinal column. In some rare cases the lumbar region is specially attacked. The frequency with which *severe skoliosis* is associated with equally *marked kyphosis* is characteristic of the deformity in syringomyelia. Kyphosis may also occur independently, and then, in the majority of cases, involves the cervical and upper dorsal regions. The curvature is rounded, an angular curvature not having been observed so far.

Vertebral curvatures are produced in syringomyelia, as stated, by the extensive atrophy of the bones of the spine. This commences usually in *individual* vertebræ of the lower cervical and upper dorsal regions and extends from them further out, unless it remains confined to a particular segment of the spinal column. As a consequence of the atrophy the supporting strength of the vertebral column is weakened, and deformity ensues under the influence of unequal strain. The rounded back is thus an exaggeration of the normal dorsal curve. The causes and effects are here similar to those which prevail in senile kyphosis, which is usually led up to by a rarefaction of the bones, and in which it is found that the bodies of the vertebræ become wedge-shaped in consequence of their diminished resistance to the vertical pressure acting anteriorly.

The effect of syringomyelia may be superadded, as stated, to an already existing skoliotic tendency due to other causes and reinforce its action. The state of affairs as regards the upper extremities is of great influence, inasmuch as it may determine the direction of the skoliosis, owing to their unequal action or to their putting an unequal strain on the thorax. If joint

affections, for example, have attacked one arm, and atrophy of the muscles exists at the same time, the greater functional activity of the other arm may bring about a curvature of the spine toward its own side. Conversely, the spine may be drawn over to the side of the arm affected, should its size and weight have been increased owing to the nature of the alterations in its bones and soft parts. Borchard has seen how in a case of this kind, with an already existing slight skoliosis, the curvature, previously concave, became transformed into a curvature with its convexity to the side of the arm affected after the onset of syringomyelia.

Occasionally there is great temporary or constant tenderness to pressure over the spinal column. This painfulness has been ascribed to *pachymeningitis*, which may ensue in the course of syringomyelia. But this explanation does not fit all such cases, since tenderness has been present in cases in which there proved to be no affection of the meninges. We may well attribute the sensitiveness of the vertebræ to the impairment of their solidity and strength consequent on the atrophic changes. The painful conditions in the back would then be analogous to those complained of by rapidly growing adolescents with early skoliosis, in whom the insufficiently consolidated bones are unduly sensitive to pressure; or they might again be comparable to the pains in the spine to which Schanz gives the term of "*insufficiency of the vertebræ*," and which he attributes to a disturbance of the proper balance as between the static requirements and the static mechanical strength. If portions of the vertebral column develop tenderness in the course of syringomyelia, they may become less mobile or actually rigid in consequence

of spastic contraction of the muscles, which aims at keeping the affected vertebræ at rest, just as in the case of tuberculous spondylitis. It is not yet determined whether rigidity may be brought about by alterations in the vertebral articulations or by processes in the vicinity of the vertebræ, corresponding to those found in syringomyelia in relation to the bones and joints.

The changes which the **thorax** undergoes are for the most part secondary and caused by the curvature of the spine. What happens is that the patient's height is lessened as the vertical diameter of the trunk becomes diminished; the upper part of the body sinks down toward the pelvis, as commonly occurs in severe skoliosis from other causes, and the interval between trunk and pelvis constituting the waist disappears. The changes in the form and position of the shoulder-blades and the ribs correspond also to those observed in ordinary skoliosis.

Marie and Astie have described a boat-shaped depression of the anterior chest wall ("*thorax en bateau*") as a characteristic deformity, which has been confirmed by Schlesinger, Déjérine and others, whereas Borchard points out that a similar condition may be induced by softening of the bones under other circumstances. Schlesinger has now and then noticed subluxation forward of the clavicles along with this trough-like depression of the thorax.

In addition to the foregoing evidences of trophic disturbances in syringomyelia, there are the changes in the **bones** and **joints** which may be ranged alongside the tabetic osteo-arthropathies, but with this difference that the localization of these lesions is quite contrary in the two diseases. While in tabes, according to the

statistics of Rotter and Büdinger, the arthropathy is much less common in the upper than in the lower extremities (in a ratio of 20 per cent., as against 80 per cent.), in syringomyelia the proportion is exactly reversed, as shown by the comprehensive records collected by Schlesinger. "In syringomyelia the joint changes attack the upper extremities with the same percentage frequency as does tabes dorsalis the lower." About a quarter of the patients suffering from syringomyelia develop these joint changes, which are unilateral in the majority, again in contrast to the tabetic arthropathies which are usually bilateral and symmetrical. Moreover, joint disease occurs in tabes at a later period of life than in syringomyelia. The joint involvement in syringomyelia is the less frequent the more distally the joints are situated. The shoulder-joint, according to Schlesinger, is attacked most frequently (about 35 per cent.), then comes the elbow-joint (about 26 per cent.), and finally the wrist (about 14 per cent.).

These *arthropathies* may set in suddenly following an injury, as is seen in tabes, or they may develop gradually. At times, accidental suppuration in neighbouring tissue is a factor. The part played by injury as the exciting cause is not always readily determined, as the effect of a trauma may be merely to aggravate a joint lesion which is already present but has not yet given rise to obvious trouble.

Just as in tabes, the joint affection may be an early sign, which calls attention to the existence of the disease in the spinal cord. When the onset is sudden, the joint becomes greatly swollen owing to an effusion in it. The swelling may also extend to the surrounding tissues. This may be due to venous congestion,

causing œdema of the limb beyond, or to the effusion rupturing the capsule of the joint and escaping into the tissues around. Severe attacks of pain may precede the sudden outbreak of the joint disease, while, in contrast to this, the fully developed lesion usually is accompanied by surprisingly little pain or tenderness.

The changes in the joints may be of all degrees, from the slightest to the most severe. In the slighter, less aggressive types the condition resembles that seen in a simple chronic arthritis without effusion. Friction sounds are heard on movement, but their intensity is not necessarily proportionate to the subjective discomfort felt by the patient. Later on, as the disease progresses in the joint, its structure becomes altered by hypertrophic or by atrophic changes, or by the two combined. If hypertrophy is the predominant factor the whole joint becomes considerably enlarged; the capsule becomes thickened and shaggy; the synovial membrane becomes fused with its surroundings, and the external layers of the capsule are notably thickened and form dense adhesions with the adjacent tissues. One often feels cartilaginous and bony nodules more or less regularly distributed throughout the capsule. New bone formations may also be detected in the neighbourhood of the joint, in relation not only to the bones but also to the soft parts. At the site of greatest pressure in the centre of the articular surfaces the cartilage disappears, while it projects as a swelling at the periphery. In the atrophic type of joint disease the capsule becomes stretched and slackened owing to the great effusion, and there is absorption of the articular cartilage and bone.

With regard to individual joints, "the typical

affection of the **shoulder-joint** in syringomyelia is an atrophic arthropathy with copious effusion of fluid into the joint" (Schlesinger). The capsule and ligaments are stretched, the glenoid cavity is broadened, the softened head of the humerus is worn away and diminished almost to vanishing point (Kofend). On this account *spontaneous dislocation* may easily happen here, and if constantly recurring is of significance as a frequent early symptom of syringomyelia (Zesas).

The **elbow-joint,** on the other hand, shows rather the hypertrophic type of arthropathy. Marked effusion into the joint takes place here also, and there is absorption of the articular faces of the humerus and ulna leading to cavitation, but these changes are less advanced than are those consisting of great thickening of the capsule and new bony outgrowths in and around the joint. There are osseous deposits in the capsule and in the adjacent muscles, particularly in the brachialis anticus and the triceps at its insertion, which becomes a bony mass continuous with the flattened olecranon. Dislocations are much less seldom found at the elbow-joint.

When the **hand** is diseased, a frequent development is an anterior dislocation, with flexion and extension greatly restricted. The radius is the more commonly displaced, if not both the bones of the forearm; sometimes also individual carpal bones. Joint effusion is not frequently present. The disease of the wrist may be complicated by suppuration which is wont to occur in the thickened and crooked fingers and to lead to necrosis. The thickening of the fingers involves both bones and soft parts, and may attain considerable dimensions. The curvature of the fingers, which produces a condition

of *claw-hand*, is partly the result of contraction of the soft parts round the joints following on suppuration and partly a result of the characteristic withering of the small muscles of the hand. The carpo-metacarpal joint of the thumb undergoes alterations similar to those seen in the large joints of the upper extremity. Dupuytren's contraction of the fingers has also been observed in syringomyelia (Testi).

In the lower extremities hypertrophic arthropathies are the most common. At the **hip,** massive new bone formation may take place, as in a case of Gnesda following on a fracture of the neck of the femur. The bone at that situation if atrophic is peculiarly liable to be fractured or cracked. On this account in most cases some traumatic alterations are demonstrable at the upper end of the femur in addition to the bony outgrowths.

At the **knee,** joint effusions and new growth of bone from the articular structures are observed. As in other chronic forms of disease of the knee-joint, contractures also tend to develop. Schlesinger has seen an acute-angled contracture here.

At the **ankle-joint** there is found swelling of the capsule and neighbouring soft parts, and also exostoses on the malleoli. Effusion in the joint is not always demonstrable.

The *bones* in general present atrophic and hypertrophic changes, which are partly independent of, and partly in common with the joint affections. Frequently, as in the joints, both atrophic and hypertrophic conditions occur together in the bones. Atrophy shows itself in an increase of the cancellous tissue and a loss of the compact tissue of the bone; hypertrophy, in a

general increase in size of the bone or merely in thickening of the compact tissue at the expense of the cancellous, that is to say an osteosclerosis. Well-marked atrophy, which is often widespread, permits of the ready occurrence of *spontaneous fractures* or of curvature of the softened bones. From hypertrophy of particular portions of the skeleton there results the formation of exostoses, which may be of all sizes and multiple.

Spontaneous fractures occur, in similar percentage to the arthropathies, much more frequently in the upper than in the lower extremities, and, according to a collected estimate made by Schlesinger, they occur in the bones of the forearm with exactly the same frequency as in all the other parts of the skeleton put together.

The *treatment* of the deformities due to syringomyelia can only be directed to conservative measures as far as these are possible. The wearing of a well-fitting supporting corset will be of service if there is a rapid increase of the spinal curvature accompanied by pain. For recurring dislocation of the shoulder-joint one will try to secure the joint by means of a shoulder cap.

In the case of the lower limbs one makes use of supporting apparatus in the form of sheath splints, but only if the power of movement is interfered with to a marked degree, and this is not always proportionate to the severity of the joint changes, as one often finds that a considerable deformity does not prevent the patient being able to walk, while the condition may improve without any treatment whatever.

If a joint effusion in the knee is severe, greatly restricting movement, and shows no tendency to absorption, it should be evacuated so as to restore the use of

the joint. With this object the joint should be emptied by incision, as, according to the experience of Borchard, puncture is unsuitable owing to the viscosity of the fluid and the presence of fibrin in quantity. In the other joints incision is called for only in the case of the elbow and perhaps the shoulder.

For the most part the excision of joints has given bad results. The question of amputation only arises in the event of a greatly deformed and wholly useless limb directly interfering with locomotion.

There is little specially to be said regarding the deformities which may ensue on other primary diffuse diseases of the spinal cord with spastic or flaccid paresis of the extremities, such as **myelitis, hæmatomyelia,** or **insular sclerosis.** Contractures are found in these conditions, similar in nature to those occurring in the cerebral spastic paralysis of the extremities yet to be described and the spinal flaccid paralysis already dealt with. The therapeutic principles stated under these heads are also here applicable.

Spina bifida may lead to flaccid paralysis corresponding to its usual situation in the lumbo-sacral region, and is only followed by spastic paralysis when, in the much rarer cases, the cleft is localized in the cervical or dorsal region. The typical deformity associated with it is talipes varus. The paralysis of the legs may be complete and accompanied by great atrophy. Usually, however, it is but partial and the tibialis anticus is specially immune, as Oppenheim points out.

The treatment of this club-foot calls for a correction of the malposition on the same lines as for paralytic

club-foot in general, and the same applies to the treatment of contracture at the knee when present.

For the sake of completeness one may make mention of the operation for spina bifida, which consists in excision of the sac, followed by plastic closure of the defect. The operation should not be performed if the severity of the paralysis indicates great damage to the cord, or if the feeble vitality of the child points to a fatal issue.

III.—Diseases of the Brain.

Infantile Cerebral Paralysis.

The subject of infantile cerebral paralysis is dealt with so exhaustively and in such detail in the monograph of Freud, that it is proposed to consider here merely the practical aspects of the treatment of the spastic paresis which is present in this condition. From this point of view it is probably better to adopt Hoffa's more general and practical grouping under the heads of the cerebral *diplegias* and the cerebral *hemiplegias,* rather than the detailed classification of Freud based upon the clinical and *post-mortem* observations.

The **cerebral diplegias,** which are also known by the name of Little's disease, comprise two chief groups. In the one are included those cases in which all four extremities are affected by the spastic rigidity; the other group presents a much less severe type of the disease, in which the upper extremities are but slightly or not at all involved, and only the lower extremities show spastic contractures. There are also various other symptoms present which originate from the cerebral affection. The clinical features marking out these two groups are not really sharply delimited, and those stated

may be looked upon as the extreme types of a continuous series of transitional forms.

The most distinctive feature of cerebral diplegia is the prominence of muscular spasm as against the manifestations of paralysis. In contrast to the hemiplegic type the legs are more severely affected than the arms. As regards the *first* group, the general rigidity of the extremities may be recognized even in the suckling, as the stiffness and lack of movement in its limbs often attract attention. In these cases the upper arms are pressed against the body, the elbows are bent up, the hands pronated, flexed or extended; the fingers are not freely movable and are bent, but they may be held straight out or even over-extended. The lower limbs are flexed at the hip and the knee, and at the same time the thighs are often so markedly adducted and rotated inward that the knees are tightly pressed together (fig. 33). Sometimes the thighs are even crossed, and can only be separated from one another with the greatest difficulty, only to spring back again into their customary position when left to themselves. Children in this condition walk upon tiptoe, as the foot is kept pointed. Frequently one foot is in the equino-varus posture, the other in the equino-valgus. Independent locomotion is possible even with spastic flexion of the knees and hips, but not so when the limbs are crossed in spastic adduction. Dislocation of the hip may ensue from severe spastic adduction and flexion. If the ligaments offer great resistance there may be a condition only of subluxation or merely a widening out of the acetabulum. As a rare coincidence, congenital dislocation of the hip and Little's disease may be both present in the one patient.

The trunk is held stiffly and inclined forward, in consequence of the spastic rigidity of the musculature, a feature to which Little drew attention. With this

FIG. 33.

increase of muscular tension acting in the vertical direction the normal curves of the spine, especially the dorsal kyphotic one, become exaggerated. Moreover, flexion-contracture at the hips by setting up a lumbar

lordosis brings about a compensatory increased development of the dorsal kyphosis. Lateral curvatures of the spinal column are less common in Little's disease. As Schulthess emphasizes, it is only particular forms with some special distribution of the paralysis and spasms that give rise to deformities of the spine.

Other symptoms which may appear in Little's disease include various disturbances of speech, such as difficulty with articulation, stammering and indistinct pronunciation. One frequently notices squinting, which may be to some extent concomitant strabismus [non-paralytic] or depending on spasm or paresis of the muscles of the orbit.

In association with the worst cases of general rigidity there are seen the more advanced degrees of motor paralysis and serious mental impairment, amounting, it may be, to absolute idiocy. Epileptic attacks likewise may appear as attendant symptoms, and also athetosis and choreiform movements.

The presence of the last-mentioned associated symptoms makes the *prognosis* unfavourable; nevertheless there are cases of a less severe nature in which choreiform and athetotic movements in the muscles of the face and extremities are more in evidence than spasticity. The squinting and the disturbance of speech may also be observed in cases of more favourable prognosis. When the facial muscles are spastically affected the expression assumes a degree of immobility, the child holds his mouth always open, and the saliva runs out, so that at first glance one may suppose the case is that of a cretin, until one finds on further investigation that it is the organs of expression that are defective rather than the intelligence itself.

When there is little if any mental disturbance and the upper extremities are normal, or at most give evidence of a slight disability in the movements of hands and fingers, such a case is included in the *second* group of cerebral diplegias; otherwise, Little's disease in the narrower meaning of the term, or congenital spastic stiffness of the limbs as Ruprecht calls it. In this, the only indication of a cerebral origin of the disease may be strabismus. If that is absent the condition is analogous to spastic spinal paralysis, to which it may also correspond on pathological grounds. The lower extremities, which alone are affected, present spastic contractures such as described, and the reflexes are active. The patella is drawn high up (Joachimsthal), owing to lengthening of the patellar ligament (Schulthess). This elongation is brought about either by the extensor muscles adapting themselves to the restricted movements at the knee consequent on the spasticity, or to stretching out of the ligament by the spastically rigid quadriceps. In the mildest cases of spastic stiffness of the limbs there may be no contractures of the hips and knees, and the only evidences of the disease are the more or less spastically altered gait and the slight degree of pointing of the feet. For the ætiology of these very mild cases premature birth was mainly held responsible by Little, whereas difficult birth was more frequently an associated cause of general rigidity.

All varieties of the cerebral diplegias have a common origin in some graduated disturbance of function of the cortico-motor neurons. Complete loss of function causes paralysis; cutting-off of a portion of the connections leads to paresis. According to Freud, rigidity occurs when the function of the cortical neuron is merely

weakened but not lost. "Rigidity and paralysis may therefore be interspersed at random and in any topical arrangement. Rigidity is thus to be looked upon as the consequence of the predominance of the spinal innervation, not as an indication of spinal irritation. The varied distribution of rigidity and of paralysis in the extremities permits then of an explanation. The cortical tract has very much greater influence on the upper extremities than on the lower. If cortical influence is wholly lacking, this must become more manifest in the arms through a greater degree of paralysis and contracture. If the cortical influence undergoes only a general qualitative degradation, it has still this significance for the innervation of the arms, namely, that they are better protected than the legs against paralysis and contracture. Paraplegic rigidity would be therefore the diminished expression of an incomplete and general disturbance of function of the cortico-motor neurons." If then we view infantile spasticity as a disturbance of the balance in the antagonistic action of the spinal and the cerebral innervation of the muscles, we may accordingly make it the purpose of treatment to seek to overcome, if not indeed the disturbed balance of innervation, at any rate the consequent disturbance of balance in the muscular antagonisms.

It will be found necessary, however, to pick and choose among the cases to be treated. A child, suffering from severe contractures of the extremities, and at the same time an idiot, will gain nothing from treatment even if the muscular balance of action is completely restored and the contractures are set right, since it is unable to take advantage of its improved condition. On the other hand, a semi-intelligent child may, with-

out great difficulty, be rendered capable of walking independently *simply by getting rid of the contractures.*

It must again be recalled here that in general and paraplegic rigidity the paresis or paralysis of the muscles is wholly overshadowed by the spastic element or hypertonus, or at most its presence is indicated by defective movement in certain directions. The power of voluntary movement in the spastic muscles is by no means lost as a rule, but only impeded, and *this power may be increased by education and practice.*

The chief obstacle to controlled and steady movements is the impetuous, exaggerated, and in some degree unrestrained action of the spastic muscles in response to the nerve impulse for voluntary contraction. A second obstacle to movement is the contracture of the joints, which results from the predominance of certain muscles, such as the adductors and the flexors of the knee and the calf muscles. In its practical aspect it is largely a matter of indifference whether this dominant muscular action, which determines and fixes the position of the joint, is to be considered as a consequence of a more intense spastic affection, or is to be ascribed solely to the already greater strength of the particular group of muscles concerned as against its antagonists. As a factor at a later stage only there occurs the gradual shrinking due to trophic cellular changes of the muscles producing the contracture, and this secondary hindrance to movement is further aggravated by similar changes in the capsule of the joint and by deformation of the articular ends of the bones.

In view of its being impossible to influence the cerebral cause of the disease, the chief problem in the symptomatic *treatment* is to equalize the antagonistic

action of the muscles as far as possible. The method to be chosen to attain this is to reduce the unrestrained power of the muscles which cause the contracture, to a degree that will permit of their properly balanced antagonism working in unison with those muscles of less spastic power which are situated on the opposite side of the deformity. If this object is properly secured, a muscle may still contract spasmodically, as it did before, but the effect of this undesirable contraction will be diminished to such an extent as to be balanced by the antagonists, while still permitting of locomotion. We arrive at this by simple tenotomy or myorrhexis of the muscles producing the contracture. The tenotomy is followed by redressment of the contractures, which should be carried out to the extent of over-correction. By this means the divided tendons become materially lengthened, a process which is initiated by the retraction of the proximal end of tendon following on the tenotomy, under the influence of the active tone of the muscle.

When all the joints of the lower limb show contractures, tenotomy, or it may be myotomy, has to be performed at six points and may be done subcutaneously in each case. For the flexion-contracture of the hip, myotomy is carried out below the anterior superior spine on the flexor muscles attached to it (tensor fasciæ femoris, &c.). The spasm of the adductors is best treated without incision by forcible stretching and rupture of the adductors (myorrhexis), or by tenotomy of the strap-like, prominent edge of the adductors. Neurectomy of both branches of the obturator nerve (Lorenz), owing, perhaps, to subsequent contraction of the deep scar, has given poorer

results than simple myorrhexis of the adductors. In the next place there follows tenotomy of the biceps, semitendinosus and semimembranosus at the back of the knee and finally a simple or plastic tenotomy of the tendo Achillis, which is preceded by remodelling of the foot if talipes varus or valgus is present. After the tenotomies the contracted joints are all over-corrected, and the legs are then fixed in a plaster-of-

FIG. 34.

Paris bandage with the thighs extended and abducted, the knees over-extended, and the feet set plantigrade (fig. 34). As regards the foot, one must avoid over-correction in dorsiflexion, because in this position the divided ends of the tendo Achillis may fail to unite.

It is true that the extended position of the joints may be often attainable by simple stretching of the muscles, but a permanent effect is not to be secured in this way. Passive extension only produces an

elongation of the belly of the muscle, and as soon as the immediate result of the stretching has passed off then the pathological innervation of the muscle leads to restoration of the previous state of affairs. If, however, after stretching of the muscle, the limb is fixed in position by bandaging, there very soon ensues a most painful cramp. Tenotomy is therefore indispensable. It introduces an extensive scar into the length of the tendon, and it is only in this fashion that a diminution in the contractile power of the muscle can be brought about and at the same time a correction of the joint contracture.

The plaster bandage, applied as above described, is left on for six to eight weeks. As the bandage extends the whole length from the iliac crests to the feet it is strengthened and made more rigid by attaching a cross-bar between the leg portions (fig. 34). There is no need at all for the patient to be confined to bed during the short time that he is wearing the bandage. The child may be taken out as soon as the plaster is hardened throughout, which usually takes a few days, and after the pain felt at first has passed off.

When the bandage is removed the treatment is by no means at an end, although the joints have been over-corrected. It must not be forgotten that to obtain an increase of power in the antagonistic muscles is no less important than is the weakening of the spastic muscles, which had determined the contracture of the joint, since the whole scheme of treatment is to readjust the disturbed balance of the muscular antagonisms. Along with the continuance of passive over-correction of the joints there is the necessity for inducing the patient to carry out steady and vigorous

voluntary movements which will act in the same direction. This second stage of the treatment calls for much more time, patience, and persistence than does the first.

The strengthening of the antagonists of the tenotomized muscles is to be gained by means of faradization, but more especially by massage and gymnastic exercises. These measures are of service, not only for the strengthening of the musculature, but also no less for educating and accustoming the muscles to respond properly to the nerve motor impulses. The whole musculature of the extremities is not to be submitted to treatment on these lines, for that should be directed mainly to the *antagonistic* muscles. While the effect of the spastic action of the tenotomized muscles is diminished by the increase in length of their tendons, the strengthening and the methodical training of the opposing muscles is to supply a further control to the unrestrained action of the former group.

In the first place, the gluteal muscles which serve as abductors and extensors of the hip are to be subjected to massage. Then, in regard to the exercises for voluntary abduction, the child is laid on its back and is got to try to spread its legs as far apart as possible. As progress is made one commences to oppose a modulated resistance to the movements of the child. Finally, the child is placed alternately on its right and left side and made to perform the abduction movement and to sustain the elevated limb for a time in the air. In this exercise the child must be able to raise the weight of its whole limb by *voluntary* movement. Extension exercises are similarly carried out with the patient lying on his face.

In addition to the gymnastics for the muscles round the hip, the passive stretching of the adductors, which were treated by myorrhexis, must not be neglected. This is done most simply by laying the patient at the edge of a table with one leg hanging free and attaching to this a weight or bag of shot of about 4 to 10 lb. In this way the limb is both abducted and extended at the hip. A more energetic method of overcoming flexion at the hip is to lay the child on its face, supporting the abdomen and the knees, and then to place bags of shot weighing 20 to 40 lb. upon the buttocks.

The extensor muscles of the knee-joint are treated on analogous principles, using at first light, and later on more vigorous massage for the quadriceps, combining this with passive extension of the joint. With this latter object the patient is laid on his back and his feet are raised up on a cushion. Shot bags weighing 8 lb., increased up to 20 lb., are then placed on the limbs over the patellæ. The time given to this is also increased up to half an hour, but only gradually, so that full extension of the lengthened hamstrings may be borne without pain. Active extension exercises at the knee-joint are best performed by the patient while lying on his back. Later on the movements should be practised against a slight resistance.

In the leg, massage is restricted to the front and outer aspect, corresponding therefore to the pronator and flexor muscles of the foot, and these muscles are voluntarily exercised, acting against a slight resistance. Should a spastic equino-valgus condition have been present, then the supinator group of muscles should be dealt with in the same way. The boots must

also be fitted, of course, with a suitable support for the arch.

Practice in walking also goes hand in hand with the special training of the muscles. The patient is supported and made to set one foot in front of the other, keeping the thighs well apart. When the child does not enjoy the free use of its arms, it needs for a long time the assistance of someone in walking. Fortunately, however, most patients suffering from paraplegia have sufficient control over their upper limbs—at least, of their hands—so that they can learn to get along by themselves with the aid of one stick or, if need be, a couple, and in the end are usually able to walk unassisted.

As already mentioned, one must make proper selection of suitable cases for treatment. The orthopædic surgeon will only labour in vain in treating an imbecile child, unable to hold its head upright, not to speak of its body. In the cases, fortunately much more numerous, in which orthopædic treatment repays the trouble expended, the therapeutic aim must always be to render the patient capable of locomotion without requiring surgical appliances. It is only when the extensor muscles are greatly weakened that it is a good plan to employ, for a short time, a sheath splint apparatus. This should be so constructed as to admit of free movement when desired, and at other times, as during the night, to secure the joints in the corrected position. When one cannot rely upon the after-treatment with massage and gymnastics being carefully carried out during a period of years, one will be forced to employ a supporting appliance of this kind from the very first, so as to prevent any relapse.

Endeavours have been made to restore the muscular balance without tenotomies by transplanting contracted muscles on to their weaker antagonists, without, however, improving on the results obtainable. On the basis of an extensive experience, Hoffa has expressed himself in favour of tenotomy, and Redard, Kirmisson, Froelich and others share this opinion.

Greater significance, however, attaches to the method of treatment introduced but a short time ago by O. Foerster, in which it is sought to control the pathological condition of innervation of the musculature by an operative procedure on the nervous system itself. Foerster's propositions in regard to this are as follows: Whereas the *cortical* excitability of the muscles is lost or, at any rate, more or less diminished on account of the interruption in the pyramidal tract, on the other hand, the *peripheral* excitability of the muscles, that is to say, their capacity for being made to contract by sensory irritation in the path of the spinal or subcortical reflexes, is not lost, but is, in fact, very much greater than the normal, apart from the cases of recent hemiplegia at its commencement and of paraplegia with sudden onset. The pyramidal tract has, in addition to its function of conveying motor impulses for muscles from the cortex to the grey matter of the spinal cord, the equally important duty of inhibiting the spinal reflex excitability and maintaining it at that modified degree which we recognize as normal. The most familiar expression of a heightened reflex excitability of the muscles in the event of an interruption in the pyramidal tract is the exaggeration of the tendon reflexes, and also various alterations in the reflexes of the skin, periosteum and soft parts. Further evidence

in this state of affairs of heightened reflex excitability is seen in the almost regular occurrence of definite involuntary associated movements, when definite voluntary movements are performed. Moreover, there ensues an abnormal involuntary contraction of the muscles, particularly when their points of insertion are brought closer to one another. One becomes aware of this increased tension of the muscles from the resistance which they then offer to extension. From this spastic contraction of the muscles there gradually develops, with shrinking of the soft parts, what is known as *myogenic contracture of the joints.*

Now, the inhibitory function of the pyramidal tract is wholly independent from its function of producing muscular contraction. When a lesion of this tract occurs and gradually increases, the inhibitory function almost always suffers first and considerably more than does the other function; that is to say, that only symptoms of increased reflex activity appear, while no actual paresis of the muscles is demonstrable on voluntary movements. One must consequently adopt the view that the inhibitory function is considerably more vulnerable than is the motor function.

If we pass now from this discussion concerning the functions of the pyramidal tract and the nature of the motor disturbances resulting from its interruption, and turn to consider the question of the appropriate treatment of these affections, it must be emphasized in the first place that, for the compensation of the paretic factor, the position of affairs in quite a number of cases is already favourable, on account of the existence of alternative paths in the anterior and the lateral pyramidal tracts. In hemiplegia, such are present in

both; in paraplegia, in the former tract at least they remain intact often for a surprising length of time, and, if these alternative paths are not collectively destroyed, the fact is that the conduction of cortical motor impulses to individual muscles is still possible to an astonishing degree, even through a minimum of conducting fibres. That the mobility of the limbs remains so seriously affected in spite of conditions which so favour compensation, is partly due to the very disturbing effect of the other contributory factor, namely, the heightened reflex excitability of the muscles. Foerster is therefore convinced that, if the symptoms of increased reflex muscular excitability can be abolished, then the paretic features would be far less in evidence, and moreover could be gradually diminished still further by exercise.

Foerster seized on the indication which human pathology had afforded when it was demonstrated that, if an affection of the pyramidal tracts coexists with an obvious lesion at the region of entrance of the roots into the lumbo-sacral cord, there are no contractures of the legs, and that, when such contractures are present beforehand, they disappear on the occurrence of disease of the posterior roots. Consequently, in the case of a lesion of the pyramidal tract, the spastic contractions, as well as the other signs of increased reflex muscular excitability, might be terminated by dividing a link in the chain of the reflex arc by *operative* measures.

The motor elements in the reflex arc, the anterior horn, anterior root and motor nerve, cannot, of course, come into the scope of operation, since their disconnection, while certainly relieving the contracture, would at the same time produce a complete flaccid paralysis of the innervated muscles.

In respect of the sensory portion of the reflex arc, the peripheral sensory nerves are so intimately blended everywhere with the motor fibres that they cannot possibly be separately divided. The disconnection of the posterior roots in the region of the root entry zone is not a practicable operation, and thus the only suitable part which can be isolated is the posterior spinal nerve root. If now the posterior roots are resected indiscriminately, there is reason to fear not only serious sensory disturbances, but also disorders of mobility in the form of ataxia. In order to avoid this, Foerster has proceeded in accordance with the results of Sherrington's experiments on animals, which showed that the sensory innervation of a particular area of the skin always is supplied by not only a chief root, but also by two accessory roots, the next above and the next below. He therefore keeps the principle in view, in making a choice of the roots concerned in the sensory innervation of an extremity, that never more than two adjacent roots are to be resected, but, where possible, only one of two adjacent.

A selection made in this way suffices also to relieve the spastic muscular contracture, since no group of muscles derives its motor innervation from only a single segment of the cord, whilst its reflex excitability is never transmitted through a single segment, but through at least three or more segments.

One must therefore, in a given case, determine which group of muscles is particularly involved in the contracture, which spinal segments transmit the reflex that induces the contracture, and then from among these segments one makes the selection on the basis that one seeks to avoid, as far as possible, resecting

two adjacent roots, and in no case resects more than two adjacent.

According to Foerster, his operation is suitable for all severe spastic paraplegias of the legs of whatever origin; accordingly in cases of *compression-myelitis, disseminated sclerosis,* and above all, however, the *congenital spastic paraplegia* of Little, described above. All the same, Foerster rightly considers that only such very serious cases as have nothing more to lose should be so treated. The operation, in fact, is a severe procedure and the mortality so far has been considerable (Codivilla), whereas the method of treatment by subcutaneous tenotomy, redressment, &c., first of all described, is quite safe. It has also to be realized that these orthopædic measures are still necessary, even after Foerster's operation has been performed, should the spastic contractures have already advanced to the stage of actual shrinking of the muscles. Only practical experience will show whether the selection of posterior nerve roots as recommended by Foerster with the object of avoiding sensory disturbances, will suffice in the severest cases of spasm to abolish it entirely. If for this purpose too many sensory roots are divided, there then exists the danger of setting up a motor paralysis of reflex origin [14].

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[14] Foerster reported to the Eleventh Congress of the German Society for Orthopædic Surgery on his operation and on the results so far recorded. He had made some modifications as to the selection of nerve roots, and he had adopted the use of the galvanic current to distinguish between the anterior and the posterior roots, instead of relying solely on anatomical features.

He had collected from the literature 119 cases of this operation, the total mortality of which was 10.8 per cent. Of these cases 59 were instances of Little's disease. Success was obtained in

It should further be mentioned that in performing Foerster's operation a defect is created in the vertebral column, and it is desirable that this should be repaired so that the occurrence of a meningocele may be obviated.

Cerebral hemiplegia, which forms the second group of the infantile cerebral paralyses, has for its etiology similar factors as in Little's disease, namely, premature birth and difficulty at birth. Freud attributes an extra-uterine origin of the paralysis in about one-third of the cases to infective diseases. Children are chiefly attacked during the first to the third year of life.

The hemiplegia is frequently complicated by disturbances of speech and mental weakness, which may amount to idiocy. Choreic, athetotic and associated movements are usually in evidence on the side affected. The paralysis extends to the arm and leg, but, as a rule, the upper extremity is more affected than the lower. The upper arm is held close to the side, the forearm is flexed and pronated, the hand most often flexed and adducted to the ulnar side, but occasionally extended, the fingers usually clenched over the in-turned thumb. The leg presents slight degrees of internal rotation and contracture of the knee, the foot is fixed in the talipes equinus or equino-varus position.

In spastic hemiplegia too, as in diplegia, there are found all degrees and transitions from the mildest to the severest type of case. Now and then the disease leaves only a residual slight awkwardness in the use of

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46 cases, but not in other 5, and there were 8 deaths. Of the non-successful cases one was an idiot and another had persistent athetosis, although the spasticity was completely relieved. (See *Verhandlungen der deutschen Gesellschaft für orthopädische Chirurgie*, 1912, p. 269, and p. 38 for clinical description and illustrations of cases.)—Translator.

the hand. The lower extremity manifests, as a rule, a greater tendency to spontaneous improvement than does the upper.

In the more severe cases, skoliosis, too, may develop and its convexity is frequently directed toward the sound side, as in spinal paralysis of the muscles of the back.

Massage and gymnastics, restricted to the weaker muscles, may suffice for the *treatment* of those mild cases of hemiplegia in which the symptoms as a whole are not pronounced, and suitable after-treatment by exercising is attended by good results.

If spastic contractures are definitely in evidence, they are to be treated in the lower extremity in the same way as in the case of diplegia. Simple or plastic lengthening of the tendo Achillis by tenotomy is often necessary. If club-foot is also present, it is first to be dealt with by remodelling. Contracture, when present at the knee, is got rid of by tenotomy of the hamstrings and subsequent redressment, and the corrected position is made secure by applying a plaster-of-Paris bandage.

By these measures the leg will be rendered thereafter fully capable of assuming its comparatively simple functions. It is a much more difficult matter to treat the upper extremity, as there arises here the problem not merely of abolishing contractures, but also of restoring in some degree the capacity of the arm and hand for performing their complicated functions. One will strive to attain this object principally by means of tendon transplantation, in order to bring increased power to the paretic muscles. Hoffa has set forth the following scheme for such operations on the upper extremity :—

Purpose of the Operation.	*Operative Procedure.*
Relief of pronator spasm.	Detachment of the pronator radii teres from the internal condyle of the humerus.
Active supination.	Hoffa's operation of pronatorplasty. Transference of the tendon of the flexor carpi ulnaris over the back of the forearm and its attachment to the periosteum on the anterior aspect of the radius (Fränkel).
Tendinous fixation of the wrist in an indifferent position. ...	Shortening of the extensor carpi radialis longior.
...	Shortening of the extensor carpi ulnaris.
...	Shortening of the extensor communis digitorum.
Active dorsal flexion of the hand and active extension of the proximal phalanges. ...	Transplantation of the flexor carpi ulnaris on to the extensor communis digitorum.
	Transplantation of the flexor carpi radialis on to the extensor communis digitorum.
	Transplantation of the extensor carpi radialis longior on to the extensor communis digitorum.
Relief of ulnar flexion. ...	Lengthening of the extensor carpi ulnaris.
Relief of the flexion of the thumb. ...	Shortening of the extensor longus pollicis.
Active extension and abduction of the thumb. ...	Transplantation of the flexor carpi radialis on to the extensor longus pollicis.
	Transplantation of the flexor carpi radialis on to the extensor ossis metacarpi pollicis.
	Transplantation of half of the extensor carpi radialis brevior on to the extensor longus pollicis.
Relief of the flexion-contracture at the elbow-joint. ...	Division of the bicipital fascia.
	Division of the biceps in front of the elbow.
Active extension of the elbow-joint (restoration of triceps action). ...	Passive transplantation of the triceps on to the deltoid (Hoffa).
Active abduction of the upper arm (restoration of the deltoid action). ...	Transplantation of the trapezius on to the deltoid (Hoffa).

By making a suitable choice of the muscles available for a plastic operation, not only is the position of the arm and hand improved, which otherwise could be brought about only by wearing for years an orthopædic

apparatus, but, in addition, voluntary use of the formerly paretic muscles is made possible and thus the hand is made again of service as a prehensile organ. Hoffa lays special stress on the effect of tendon grafting in relieving spasm. The statement of Wittek is noteworthy that he observed transplantation to exercise a favourable influence on *choreic* movements.

The more complicated, however, the loss of function happens to be, so much the more complicated becomes the transplanting of tendons, and consequently the final result of that procedure affords merely a cosmetic, but not a functional success as well. It would seem to be evident that in such cases a more centrally directed operative interference, that is to say, on the nervous system itself, will be more likely to bring about a peripheral adjustment of the disordered muscular antagonisms, provided, of course, that the operation is successful.

In this respect Foerster's operation of spinal root excision is still in the experimental stage [15], but on the other hand, Spitzy's endeavours to secure the

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[15] The results of this operation recorded by Foerster (*loc. cit.*) in cases of spastic paralysis of the arm cover 15 instances. Of these, 2 died, but in 9 a successful result was reported. In the remaining 4 no benefit ensued, as in 2 of them a complete flaccid paralysis took the place of the previous spastic condition, and in the other 2 no real improvement in the usefulness of the arm followed partial relief of the spasticity.

Foerster also describes the results obtained in spastic conditions of varied nature, such as acquired cerebral disease in early youth (6 cases due to syphilis, hydrocephalus, &c., 4 of them more or less successful); spastic paralysis of the legs due to syphilis of the cord (4 cases, all successful); true spastic spinal paralysis (2 successful cases); spinal caries with spastic paralysis of the legs (1 successful case); traumatic spinal paralysis (3 cases, 1 of them successful and 1 partially so); and insular sclerosis (8 cases, of which 4 died, and of the others 2 were successful).—Translator.

desired result by means of *nerve grafting* have already afforded some successes.

As the position of the spastically affected hand is characterized by a predominance of the muscles innervated by the median over those supplied by the musculo-spiral nerve, thus presenting the appearance typical of musculo-spiral paralysis, and as we have neuro-muscular connections to deal with, which are quite intact, the prospects in neuroplasty are accordingly as favourable as could be imagined. In a case of this kind Spitzy relieved for the most part the disturbance of associated muscular actions by a central partial transplantation from the dominant median on to the musculo-spiral nerve. As subsequently a marked adduction of the thumb was still a cause of inconvenience, the adductor pollicis muscle, supplied by the ulnar nerve, was divided subcutaneously close up to its insertion in the bone. In the course of three or four months the hand, previously useless, was able to pick up, grasp and hold things.

Finally, reference should be made to the effect of *diminishing tension* in paralysed muscles (Lorenz). Time and again one will find that even a trivial disturbance of muscular balance is sufficient to lead up to the development of a deformity. As this progresses the muscles which are functionating and are situated on the concave aspect of the deformity, undergo shortening and shrinking, while the weaker muscles on the convex aspect of the curvature become stretched and lengthened. Even though these have not been totally paralysed they lose all power of action owing to their state of passive tension, and finally develop the condition of paralysis from disuse. Since these muscles

on the convex side suffer more than do the shrunken ones on the concave side, the disturbance of muscular balance increases *pari passu* with the deformity. As the deformity becomes more marked the severity of the paralysis and the extent of the disturbance of muscular balance are readily liable to be over-estimated. We therefore consider that the first and foremost task in dealing with the deformity is to restore the conditions existing before the growth of the deformity, so far at least as concerns the over-stretched muscles.

There may well be explained on this basis the good results which Bardenheuer has obtained in spastic infantile hemiplegia by simple *myotomy* and *myorrhapy*. Bardenheuer, by dividing them, lengthens, and weakens the power of the hypertonic muscles innervated by the median and ulnar, and he shortens the lengthened, hypotonic muscles innervated by the musculo-spiral. The upper arm is also included within the scope of the operation. Accordingly, in addition to muscles supplied by the median, the pronator radii teres, the flexor carpi ulnaris and radialis, and the long flexors of the digits, the following muscles are divided in the upper arm also: the biceps, the brachialis anticus and the pectoralis major. The tendons are shortened in relation to the extensors of the fingers, the extensor ossis metacarpi pollicis, the extensor longus pollicis, and the extensor carpi ulnaris and radialis.

The importance of the *after-treatment* subsequent to all the operative methods mentioned should not fail to be appreciated. It consists in fostering the condition of the functionally weaker muscles by means of

electrical treatment, massage and exercises, and these must be persevered with and continued for a long time.

In the **hemiplegias of adults** the question of operative treatment depends above all things on whether the patient can stand an anæsthetic or not. In the latter circumstance the contractures must be opposed from the beginning with the help of electrical and mechanical treatment. Frequently the aid given by some form of ambulatory appliance is indispensable. One is most frequently called upon to remedy a club-foot condition. For this a sheath splint apparatus is of service, made to enclose the leg and foot, and fitted with strong rubber bands so applied as to produce dorsal flexion of the foot (fig. 27) [16]. Less frequently we may have to employ a sheath appliance fitted with elastic bands for extension of the leg at the knee. In the upper extremity, the marked palmar flexion of the hand and the fingers gives rise to the most trouble. To overcome this, one makes use of a sheath splint for the forearm and hand, and the hinge is designed to permit of extension of the hand by a rubber band. Heusner's glove is the simplest appliance for obtaining extension of the fingers (fig. 17) [17].

In addition to the above, the muscles opposed to those producing the contracture are strengthened by electricity and massage. Gymnastic measures are also employed. At first, passive movements are made in the direction of action of the weaker muscles and lead up to the practising of similar voluntary movements later on. Simple tenotomy may perhaps be performed under local anæsthesia.

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[16] See p. 145. [17] See p. 77.

IV.—Neuroses.

Hysteria.

One of the numerous and varied clinical features presented by hysteria is what Charcot called the "*diathèse de contracture.*" This tendency to contracture formation is seen in single muscles or in groups, in response to even the most trivial of external stimuli. Quite a slight movement, which one makes with the muscle, and even mere verbal suggestion, may be sufficient to set up a contracture which is easily suppressed, however.

We would leave out of account here the tonic spasms which may occur in the earliest stages of a severe hysterical attack. These are *transient* and therefore not to be designated as "contractures," the characteristic of which is the *permanent* retention of an abnormal position.

Hysterical contractures manifest themselves in great variety, and may imitate the most diverse deformities such as commonly occur in affections of the nervous system and locomotory organs. Hysterical contractures owe their origin to the psychical alteration evoked with such particular ease and peculiar to hysteria. A quite trivial sensory stimulus, which would give rise to no obvious effect in the normal person, is sufficient to set free in the over-sensitive, hysterical individual a powerful motor reaction out of all proportion.

This reaction is evidenced in the contracture of the muscles or groups involved, whether the sensory stimulus arose from the contracted muscles themselves or from their immediate neighbourhood. In the same way as in organic joint disease with associated spastic

contracture of the muscles around the joint, hysterical contracture has also as its aim to make a stimulus of painful nature more bearable, by the maintenance without movement of a definite posture. Thus an *articular neuralgia* occurring as a hysterical manifestation may induce a contracture of the muscles controlling the joint. It is typical of hysterical contracture associated with an injury, a *traumatic neurosis,* that the contracture persists long after the direct effects of the injury, as of a joint for instance, have disappeared.

"After the original sensory stimulus has passed away, the painful sensations that are felt in the muscles and ligaments of a limb kept for a long time at rest determine the persistence of the hysterical contracture, and even lead to further exaggeration of it. It is all one whether the posture has been adopted spontaneously by the patient or has been produced passively by the bandages" (Trappe).

In most cases, as Bruns points out, the hysterical contractures remit during sleep. In contrast with this, in a few cases he was unable to push chloroform anæsthesia far enough to produce relaxation of the tension in the limbs; before the patient had yet fully wakened from the anæsthesia, the contracture had always resumed its previous state.

Another characteristic of hysterical contractures is their response to psychic impressions. What Oppenheim has put forward as specially notable is that the contraction of the muscles at once increases on any attempt (which usually causes great pain) to overcome it, often indeed on the mere touching of the limb; and further that the approximation of the points of attachment of a muscle does not conduce to its relaxation,

which, on the other hand, that procedure does effect in the contracture that is associated with true hemiplegia.

Observations have been recorded of *hysterical wry neck* in which sometimes no exciting cause at all could be discovered (Hoffa), or there was only a slight infiltration in the sternomastoid, which could have given rise to but little discomfort (Lilienfeld). We have seen a case of hysterical elevation of the scapula, and Lilienfeld has described in detail a similar one, in which the shoulder-blade was tilted upward and forward so that the inferior angle of the scapula projected. The cause of this was a spasm of the two rhomboid muscles which the patient was able to relax, though but for a short time, and likewise the shoulder-blade could be depressed passively.

When the **upper extremity** is affected, the arm is usually pressed against the chest with the elbow bent, the fingers and hand commonly flexed to the utmost, occasionally, however, extended. The joints of the **lower extremity** are, as a rule, in the position of extension. Hysterical contracture of the *hip* deserves special mention. It may commence like a tuberculous coxitis, especially resembling this when there is at the same time a neuralgia of the hip-joint, which starts the spastic contracture of the muscles around. A correct diagnosis in such a case is not always possible straightway, and only a thorough general and local investigation is able to reveal the true state of affairs. The joint is then found to be less painful than are the neighbouring soft parts, and by acting on the patient's psychical condition it may often be possible to render the affection more bearable, and not only that but even to bring about complete recovery. A combination of neuralgia with

flexion-contracture is frequently found at the knee-joint, while the foot may assume an equinus or equino-varus position, and the toes are usually flexed, less often extended.

Like the extremities, the **trunk** also is subject to alterations owing to various muscular spasms. That most commonly seen is *skoliosis,* less frequently *kyphosis,* and rarely *lordosis.* It is a feature of these affections that they consist solely of some anomaly in the posture, which is dependent partly on static considerations, and partly on muscular action. There is therefore an absence of those anatomical changes in the skeleton of the trunk, such as are to be observed in the ordinary spinal curvatures. In hysterical skoliosis there may thus be seen a lateral deviation of the trunk, but without those changes in the thorax which are found in other cases of skoliosis and are consequent on the rotation and torsion of the vertebræ, so there is no hump formation in the ribs demonstrable. With an existing tendency to skoliosis, however, the maintenance of the faulty posture of the spine over a long period of time probably may give rise to an actual skoliosis, or an aggravation of an already present deformity of the kind.

Hysterical *skoliosis* may have a static origin in the event of a certain hysterical disposition of the hip having already occurred, such as was first observed by Wertheim-Salomonson, and later by Schoemaker, Scheu, and others. In this abnormal posture, to which Wertheim-Salomonson gave the name of "*attitude hanchée,*" the position assumed is like that seen when a person, tired by long standing, lets one hip drop and bends the leg of the same side at the knee. Owing to

the depression of the pelvis on this side, the lumbar spine must be curved convexly in the same direction. If there is no such abnormal depression of the hip, hysterical skoliosis is caused merely by contracture of muscles of the back, and is then comparable to the other hysterical contractures. It also arises in connection with injuries or is attributed to such and develops suddenly, but usually the onset is gradual.

The spinal curvature is dorso-lumbar as a rule, convex to either right or left (Hoffa), but instead of the curvatures of the whole spine one may find also partial ones, for instance, right convex cervico-dorsal skoliosis combined with left convex dorso-lumbar skoliosis (Hildebrandt). "Hysterical skoliosis does not apparently present a constant type. Its hysterical origin may be recognized much more readily from the circumstance that it develops rapidly and sometimes, too, disappears quickly, to reappear once more on the most trivial causation" (Zesas).

Pathological changes in the thorax are lacking, as has been said, and so the "skoliosis" disappears when the trunk is bent forward or when it is suspended. It permits of passive correction, and indeed the patient, when spoken to, may be able independently to abandon the skoliotic posture if only for a short time. Besides the common symptoms of hysteria, pain may be felt and referred partly to the vertebral column itself, partly to its surroundings; but it is never so constant and definitely localized as in an organic disease of the spine.

As Hoffa points out, in correspondence with the contracture of the muscles of the back "the trunk is held somewhat stiffly as a whole, and in walking the weight of the body is thrown on the leg of the side opposite the

painful contracture, while the leg of the same side often assumes a position of marked contracture. If the erect attitude is maintained for a considerable time, the spinal curvatures usually become more evident, and in some few cases they diminish or even disappear in the recumbent posture."

Hysterical *kyphosis* is much less frequent than skoliosis. Zesas has described the cases occurring in the literature, and they refer for the most part to kyphosis of the lumbar region. In such a condition the patient appears doubled-up, with the trunk thrust far forward. While in hysterical skoliosis the erector spinæ is particularly subject to contracture, here the ilio-psoas is most specially affected. Among the rare forms is contracture of the muscles in the neck, leading to kyphosis of the cervical region (Arnheim).

If the contracture is severe it may only be possible to straighten the curvature during sleep or under an anæsthetic. If pain is complained of, as may also happen in hysterical skoliosis, it is necessary for the differential diagnosis to exclude other spinal affections of organic nature with similar symptoms, the more so as the hysteria may occur as a complication of them. In one case under our observation, along with typical manifestations of hysteria there existed a spinal caries of the cervical vertebræ with compression-myelitis which led to a fatal termination (Saxl).

Angular curvature, which is peculiar to spondylitis in an advanced stage, will certainly not be confused with the *rounded* curve of hysterical kyphosis, but if the deformity that is diagnostic of spondylitis is not present, doubts may perhaps arise, which a skiagram may serve to put at rest. A clinical picture resembling

that seen in hysterical kyphosis may also be produced by chronic ankylosing inflammation of the spine and by chronic muscular rheumatism of the back.

Hysterical *lordosis* is one of the rarities and has been observed by Von Hoesslin and Riedinger. The condition is explained by functional weakness of the gluteal muscles, in consequence of which the pelvis sinks forward, thus giving rise to lordosis of the lumbar spine.

The *prognosis* of hysterical spinal curvatures is the more favourable the earlier they are treated and the more youthful the patient. The conditions occur at various ages, from the 8th (Paoli) up to the 45th year (Miraillié), and in both sexes, but it is particularly the female sex at the age of puberty that is affected in this way. Like the spinal curvatures, hysterical contractures *per se* are amenable to treatment.

Treatment of hysterical deformities must resolve itself above all into psychotherapeutic measures, which will be assisted by various other means, which may be left to the ingenuity of the medical attendant. One may thus avail oneself with advantage of massage and exercises in spinal curvatures, combined with passive correction of the deformity. One seeks in this fashion to oppose the predominance of the contracted muscles on the one hand, and on the other to strengthen the functional activity of their antagonists. When one has to deal with hysterical joint contractures one adopts similar procedures. One may also set a contracture right without any difficulty under anæsthesia, and then fix the extended joint for a time in a rigid bandage.

A warning must be uttered against any sort of operative surgical treatment of contracted muscles. In a case of acquired elevation of the shoulder-blade caused

by tonic muscular spasms, Manasse removed the major part of the affected musculature of the shoulder in three radical operations. At the end of it all, there persisted painful twitchings of the serratus magnus, which were only got rid of after twelve months of electrical treatment.

LOCALIZED SPASMS OF MUSCLES.

Spasm of the Muscles of the Neck.

Tonic or clonic spasms of the muscles of the neck lead to the jerking movements with which we are familiar, or to abnormal attitudes of the head, and in the absence of a definite apparent cause are to be distinguished from wry-neck conditions such as those due to affections of the muscles of the neck, rheumatic and congenital torticollis, or such as spastic torticollis due to caries of the cervical vertebræ.

A rotary spasm (*tic rotatoire*) is also met with, in which spasmodic contraction of the obliquus capitis inferior muscle sets up a twisting movement of the head. Spasm of the splenius moves the head backward and slightly toward the affected side. Spasm is most frequently seen in the muscles innervated by the spinal accessory, but often it is not limited merely to this region but may extend to involve adjacent muscles.

With spasm of the trapezius the head is moved backward and turned toward the affected side; with spasm of the sternomastoid the head is inclined to the affected side and rotated to the opposite side, and the chin is then slightly tilted up. The spasms may also occur bilaterally.

Tonic spasm of the rhomboid muscles and of the levator anguli scapulæ produces an elevation of the

shoulder-blade, as was mentioned in describing the hysterical contractures, but, as Oppenheim states, every such condition must not be looked upon as a hysterical manifestation.

For the *treatment* of these often extremely obstinate spasms orthopædic measures are adopted as well as internal remedies, electrical treatment, and hydrotherapy. Gymnastic exercises are carried out on the lines of getting the patient to strive independently to fix his head, which he may practise in front of a mirror so as to control his movements (Meige and Feindel). The method of inhibition treatment recommended by Oppenheim may also be mentioned. Massage of the muscles is further employed and also drill exercises of the head, such as turning, bending, circular movements, &c., performed at the word of command. Hoffa made successful use of the following passive and active exercise in a very severe case of spasm of the spinal accessory :—

A rubber cord is passed beneath the armpit of the sound side and then round the head several times, drawn tight and made fast. While the head is thus pulled over toward the sound shoulder the patient holds a heavy weight in the hand of the affected side, by which means the elevated shoulder is depressed, and he then swings to and fro the arm holding the weight. In this way the points of insertion of the contracted muscles are drawn apart and the muscles at the same time are stretched and exercised, while the stretching exerts an anti-spasmodic influence.

In severe cases one also has resort to splinting apparatus. One might then have a neck collar made up from a plaster cast (fig. 22) [18], but it is often

[18] See p. 114.

ineffective as the muscular spasm can overcome even this resistance. Our experience of fixed plaster-of-Paris collars has been still less satisfactory. In one such case the plaster bandage had to be removed shortly after it had been applied, because the patient who was neurasthenic developed a state of most intense distress which nothing would relieve, and at the same time the clonic jerking of the head increased in severity.

As a last resource, which, however, is also uncertain, there is the operative treatment. Kocher's plan is division and resection of the sternomastoid, or division of almost all the muscles in the affected region.

Simple division or stretching of the spinal accessory nerve is often without benefit in spasmodic torticollis, but some recoveries have been reported after resection of the nerve.

From an analysis of ninety-five collected cases of spasmodic wry-neck treated by operation, Kalmus concludes that resection of the cervical nerves, especially if combined with previous resection of the spinal accessory, is better than Kocher's division of muscles. Even though paralysis results from the operation, this is more readily endured than is the distressing spasm. Nevertheless the result of operation always remains a matter of doubt, for, as Oppenheim emphasizes, the *central* nervous excitation remains, and this, when one path is cut off, may discharge itself by another.

For *general* or *localized tics* elsewhere, success has likewise been obtained from exercises directed to maintaining at rest the affected parts of the body, as recommended by Brissaud, Oppenheim, Meige, and Feindel. The exercises are tried at first for short periods, to be extended later on.

Oppenheim also employs his method of *inhibition treatment,* which consists in practising the repression of reflex, defensive and emotional movements. To avoid overtiring the patient by too long continued exercises of this kind, one interposes appropriate ordinary gymnastic evolutions, the active movements affording the patient an agreeable change from the enforced state of repose.

Occupation Spasms (Craft-neuroses of Co-ordination).

The spasms associated with certain occupations, or *craft-neuroses,* are functional diseases caused merely by impairment of co-ordination, and from both the pathological and the therapeutic standpoints are to be distinguished from those spasms and paralyses and painful conditions occurring in certain occupations, which have an organic origin associated with some peripheral disease process.

When repeated demands are made on some particular group of muscles in persons who work with their hands, the periosteum at the insertions of the muscles may become irritated and give rise to radiating pains. Remak has seen in violinists an obstinate hyperæsthesia of the pulp of the left forefinger as the direct result of the pressure on the instrument.

Persons who play the piano frequently and for hours on end, especially young females, are liable to suffer from pains, which are felt not only in the hand but also in the arm up to the shoulder. Zabludowski attributes the pain to a condition of sprain, to tenosynovitis with or without noticeable effusion, or to a myositis. The conditions which commonly give rise to this are that

the keys of the piano are too broad for the particular hand, or that pieces are played which call for too great stretches. Similar trouble is experienced by violinists who have difficulty in stretching large intervals and persistently practise them.

Overstraining of particular groups of muscles will produce paresis or paralysis the more readily if, in the course of the occupation, there is direct pressure on the muscles or nerves concerned. It would lead too far to refer to all occupations which are liable to such affections and which have been described by Remak in detail. Neuritis starting under similar circumstances is also capable of setting up in the associated muscles reflex spasms, which, though of organic origin, present the greatest similarity to the genuine functional craft-neuroses.

Certain disabilities in writing, too, which appear in cerebral and spinal disorders must not be confused with the genuine writer's cramp. The disordered caligraphy observed after apoplexy belongs as little to this class as does the shaky handwriting of a neurasthenic, who may recover his normal hand as the result of mere suggestion. This last-mentioned type has close resemblance, however, to the sufferers from writer's cramp who are at the same time neurasthenically inclined, a combination frequently to be noticed.

In those cases of the kind which simulate a craft-neurosis it is necessary that one should treat the causal disease. It is thus possible to bring about the disappearance of an occupational disorder by treatment of a circumscribed periostitis, an arthritis, tenosynovitis, myositis, neuritis, and such like as may be discovered. The "played-out" fingers of the pianist are therefore

treated on the regular surgical lines. Injured joints or muscles are put at rest in severe cases by a firm bandage, and when the acute stage has passed off massage and modulated gymnastic exercises are employed. In the slighter cases one may start with massage at once, and later on supplement it with exercises. The massage takes the form chiefly of kneading the parts affected and also of stroking movements. It should be applied at first lightly, but more vigorously in the later stages, especially in chronic relapsing cases. It is found desirable to include the forearm in the massage, and sometimes the upper arm and shoulder as well. According to Zabludowski, the exercises should only be commenced when the inflammatory process has subsided, and, in contrast to the massage procedures, they should be the more energetically carried out in connection with the joints at a greater distance from the seat of the trouble. This plan merely aims at preventing any marked muscular atrophy.

A less frequent form of trouble experienced by pianists is that of cramp, and in this condition the spastic is much rarer than the paralytic type. For these cases Zabludowski recommends vigorous massage of the whole arm and exercising of all the joints. If the playing of the piano is resumed, the time given to it must not be too long without a rest, and above all it is necessary to avoid technically difficult compositions. The suggestion of Zabludowski, that in all severe cases a piano with narrower keys should be tried, is certainly worthy of consideration, as also that the youthful violinist should not commence straightway to practise on the full-sized instrument.

In the true *writer's cramp* one distinguishes a *spastic*,

a *paralytic*, a *neuralgic* and a *tremulous* form. The tremor in the hand is often associated with the weakness of the paralytic form. Pain by itself is not a common cause of the inability to write; usually it accompanies one of the three other types. The most commonly found is the spastic variety of cramp, in which the flexors of the fingers are affected by the tonic spasm much more frequently than the extensors, and, as regards the former, the thumb and forefinger are especially liable to suffer. The cramp may, however, extend to the muscles of the forearm, and even the pectoralis and deltoid have been observed to be implicated.

The *treatment* of writer's cramp demands in the first place a period of abstention from all writing, at any rate in the customary manner which is giving rise to the cramp, and, if necessary, a re-education of the co-ordination or perhaps a correction of a faulty mode of writing.

For their strengthening effects on the patient, hydrotherapy and the galvanic current may be employed. Treatment of a general character is the more desirable, as sufferers from writer's cramp are mostly neurasthenics and require rest more than anything. Most recently, good results from venous congestion have been reported (Hartenberg, Bucciante).

Errors in the method of writing consist partly in the attitude of the person writing and partly in the materials that he uses. He should take care to write on smooth paper, to use soft nibs, and to have the ink-bottle well-filled, so that he may not have to press unduly with the pen nearly dry. The length and thickness of the penholder should be suited to the

patient's hand. Zabludowski sometimes recommends a penholder with four flat sides, so that painful pressure is obviated, the pressure being then more evenly distributed on the pulp of the forefinger.

The writing-table must be sufficiently large to give proper support to the arms. The adoption of a change from the usual posture for writing has often proved beneficial. This applies not only to the whole body, which may need to be turned more to the right or the left at the table, but the position of the hand and fingers also requires to be supervised. The least amount of strain is caused when the fingers grasping the pen are held at an obtuse angle. If tender spots are present on the ulnar side of the forearm when the hand is used in its customary position, a more complete pronating of the hand may relieve this discomfort. In order to save undue strain on the muscles of the forearm, it should be moved from left to right parallelly after every second or third word.

As Zabludowski points out, one may arrive at good results on these lines alone in dealing with the paralytic or neuralgic forms of cramp, but something more has to be done for the more severe forms with tremor and spasm. A new mechanism of co-ordination may be employed, so that the previous association of movements is dispensed with. This is attained by making the hand used for writing take up a reversed position so that the palm is directed upward. The penholder is then held between the thumb and the palmar surfaces of the fingers, but it remains to be discovered whether satisfactory writing is really possible in these circumstances. The idea of this method is to transfer the work done in writing from the flexors to the extensors,

when the flexors are subject to cramp. But if the cramp has attacked the extensors as well, so that the whole musculature of the hand must be spared exertion, then the suggestion made by Gowers calls for consideration. He recommended that the writing should be done from the shoulder, the hand muscles merely serving to steady the pen, while the finer movements necessary in writing would be produced at the shoulder-joint, aided by excursions of the elbow-joint.

If tremor and cramp make their appearance when the first exercises in ordinary penmanship are being practised, it is advised by Zabludowski that the first attempts should be directed to forming large rounded capital letters, using the whole arm for this. The hand used in writing should be steadied merely on the back of the last phalanx of the little finger, and the arm as a whole left to move freely. In this practice it is best to use a soft lead-pencil. Later on, when taking up the writing of ordinary characters, the patient will make the work considerably easier for himself by rounding off all sharp corners of the letters.

In bad cases the patient may do well to learn to write with his left hand, or to adopt one of the special appliances which have been devised for use in writer's cramp and which work satisfactorily in suitable cases. The apparatus may be employed at the very beginning of treatment if the patient is unable to rest from his occupation. The best-known pattern is Nussbaum's bracelet (fig. 35), which consists of a flattened oval band made of gutta-percha, 3 cm. ($1\frac{1}{4}$ in.) broad and 2 to 3 mm. ($\frac{1}{8}$ in.) in thickness. This bracelet has, depending on the size of the hand, a long diameter of from 9 to 11 cm. ($3\frac{1}{2}$ to $4\frac{3}{8}$ in.), and a short diameter

of 3 to 5 cm. ($1\frac{1}{4}$ to 2 in.), and is thus broad enough to let the patient slip in all his fingers. Only the first four fingers are inserted, however. The thumb is introduced only for a short distance, the ring-finger up

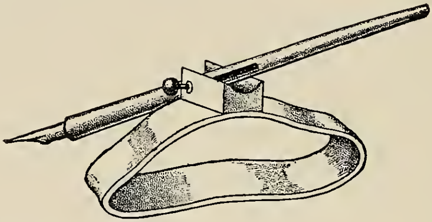

FIG. 35.

to its base, while the little finger remains outside. This bracelet can only be held firmly by stretching the fingers well out, that is to say, by the use of all the extensors of the first four fingers and the abductors of the thumb. Contraction of the flexors lets the bracelet

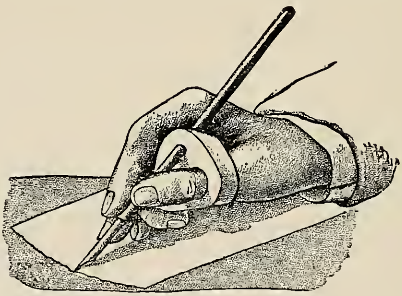

FIG. 36.

fall from off the fingers. The more the extensors are put into action, the firmer is the control over the bracelet as it guides the pen, and the better therefore the writing. The Nussbaum bracelet is thus adapted for use in spasm of the flexors and adductors.

The device of Guth is very simple (fig. 36). It consists of a piece of cork in which both thumb and penholder are inserted. As the guidance of the pen is thus transferred to the hand as a whole, the strain is taken

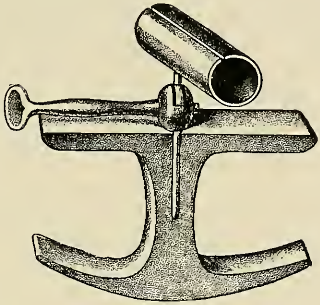

FIG. 37.

off the flexor profundus which bends the terminal phalanges.

Zabludowski's penholder (fig. 37) consists of an anchor-shaped appliance which is thrust between two of the fingers. The penholder is secured in a split

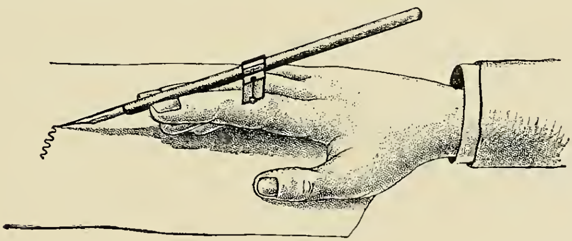

FIG. 38.

tube attached to the middle of the upper plate by an adjustable hinge, which permits of the pen being set at any desired angle and is then fixed by a screw. This apparatus can be held between any two adjacent fingers, the thumb excepted, and the pen can be directed in

various ways. It is thus possible to exempt two fingers at a time from taking part in the act of writing (fig. 38). A further feature is that the position of the fingers may be varied. Thus, if the vertical stem of the instrument rests between the proximal phalanges of two fingers and the pen is suitably adjusted, writing can be done with the fist closed (fig. 39).

The best remedy is to procure a typewriter, and the extended use of this machine by those whose occupa-

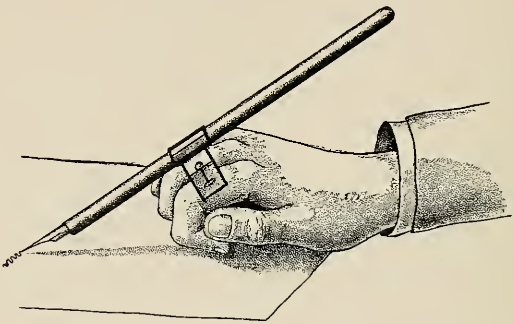

FIG. 39.

tion is writing will, in time, relegate the existing forms of writer's cramp to the history of medicine. But it must be noted that now and then disorders of a like nature occur even in those who work with a typewriting machine.

The same therapeutic principles that are followed in writer's, pianist's, and violinist's cramp are also applied in the other categories of craft-neuroses, such as are observed in 'cello and flute players, telegraph operators, sempstresses, tailors, cobblers, watchmakers, and so forth.

CHAPTER VI.

Diseases of the Locomotory System.

Rickets.

In the treatment of *rickets* there are two principles directing us; the one, to improve the disordered state of metabolism by the aid of the familiar dietetic, medicinal and physical remedial measures; the other, which demands consideration from the very commencement of the disease, to anticipate the development of deformities, or at least to prevent their reaching any severe degree.

Toward the end of the first year of life rickets usually manifests itself in changes in the trunk and the upper extremities; in the second year the pelvis and lower limbs are commonly attacked. The lack of tone in the muscles, which is characteristic of rickets, is of significance in regard to the occurrence of deformities in the disease, a feature to which attention has been specially drawn by Hagenbach-Burckhardt. As a consequence of this the limp **spinal column** may become curved under the influence of the body-weight, not only in the sitting posture, but also in the

recumbent position, if what the child is lying on yields to its weight. The dorso-lumbar *kyphosis* in rickets usually arises in this latter fashion, while the kyphosis somewhat lower down in the lumbar region is the result of the sitting posture being maintained over a lengthy period. If the trunk is not held symmetrically a rachitic *skoliosis* may be the outcome. If a child, for instance, is being constantly carried on the left arm of its nurse, it seeks to obtain sufficient support for its weak body. It rests its body, therefore, against the upper arm and shoulder of the person carrying it, and in consequence the spine is curved with a convexity to the left side. The position of the pelvis of the rachitic child will depend on the angle formed between the forearm and upper arm of its nurse, and this will also have its effect in determining the direction of the lateral curvature of the spinal column. It is characteristic of rachitic skoliosis for the summit of the curve to be placed about the middle of the vertebral column, where the dorsal passes into the lumbar region. The principal curvature is followed by the development of contrary curves above and below. Rachitic kyphosis presents a rounded curve which may be straightened wholly or at least partially without causing pain, and is thus well differentiated from the fixed, angular, and painful kyphosis of spondylitis.

The *prognosis* in rachitic kyphosis is very much more favourable than it is in rachitic skoliosis. While the latter but seldom passes off, the kyphotic condition, so long as it has not become fixed, may disappear when the child begins to stand and to walk. The lordosing of the lumbar region, which is necessary at this stage, counteracts the deformity.

Mechanical *treatment* of the rachitic deformity of the spine is most advantageously carried out with the patient in the horizontal position. The firm horse-hair mattress, which is commonly recommended for this condition, is not sufficient, though it may be used in case of necessity. A better plan is to apply a plaster-of-Paris bed, which not only affords a support for the weak back, but also serves to help in the correction of the deformity. In the case of kyphosis the plaster bed is put on with the trunk in a lordotic position. In rachitic skoliosis the part of the plaster bed opposite the bulge on the ribs is modelled flatter, so as to have a redressive action. The corrective value of the plaster bed is enhanced by passive redressment of the curvature by manipulation carried out daily, and at the same time vigorous massage of the muscles of the back is also employed. The child is kept to its plaster bed during the night, and for some hours during the daytime as well.

As soon as the little patients begin to learn to stand and walk, the erect posture of the body tends to transform the kyphosis of the lumbar vertebræ into a lordosis, and on that account it is not necessary to treat this condition subsequently with a corset, which, on the contrary, is required in rachitic skoliosis.

When rickets has affected the **lower limbs** toward the end of the second year of life, the treatment of the resultant curvatures must be mainly general and medicinal. The wearing of an appliance during the day for support or for the correction of deformity can only be relied upon exceptionally. As a rule, its efficacy is uncertain and is outweighed by the harm done to the musculature, which becomes atrophied

when an apparatus is constantly worn. On the other hand, a corrective splint may be employed during the night-time with good results.

Operative correction of rachitic curvatures of the legs should not be employed too hastily. One should wait, if possible, till the disease has passed off, and should therefore delay till the fourth, fifth, and sixth years have elapsed, since experience shows that the curvatures will often right themselves within this period. If, however, when carrying out conservative treatment one finds the deformity steadily increasing and complicated compensatory curves being formed, a longer delay is not indicated, and one will proceed to correct the crooked bones by means of osteotomy or osteoclasis, even before the lapse of the time above mentioned (Von Aberle).

In addition to the curvatures in the legs a rachitic flat foot may develop, which also calls for suitable care and attention.

In association with the rachitic deformities mention is also to be made of those caused by **osteomalacia.** In this disease, too, one meets with deformities of the thorax and legs which are attributable, as in rickets, to diminished strength of the osseous structure. Very marked curvatures may be induced by the effects of strain, body-weight, and muscular action, and demand effective treatment of the causal disease.

In the acute stage, just as in early rickets, a recumbent apparatus, such as the plaster bed, is a useful help, giving support and fixation and acting in the relief of pain. Later on it is advisable to prescribe a supporting corset or other suitable appliance.

Acute Articular Rheumatism, Rheumatic Fever.

Before, indeed, salicylic acid came into use as a specific remedy for articular rheumatism, the treatment of this disease by stiff bandaging was an accepted procedure. The benefit derived from the use of a fixative bandage is due to its protecting the inflamed synovial membrane, which is swollen and acutely sensitive, from the extreme pain which the slightest movement or disturbance sets up. For this reason the value of combining mechanical with the medicinal treatment of the affected joints is apparent.

The most elementary way of resting the joints is to ensure their being laid in what is generally recommended as the correct position. For this, the limbs must be supported at every point and their pathological position, usually one of slight flexion, must be taken into account. Better security is obtained from a wet compress bandaged round, and the moist warmth is often found to be beneficial. Since this simple circular bandage gives relatively little fixation it is better to use a rigid form of bandage. This may be secured by including splints of cardboard, wood, &c., in the wrapping, or by using starch bandages stiffened by strips of veneer-wood, or lastly plaster bandages. All these splinting materials are applied over stockinette placed next the skin, covered with a padding of wadding of suitable thickness, which is kept in place by a soft calico bandage. It is important to bear in mind that, for efficient fixation of the joint, it is necessary to include the limb above and below for some distance in the bandage.

The state of the **foot** calls for special attention when the joints are inflamed. The consequent relaxation of

the articulations leaves the foot in a condition less fit to withstand the strains normally put upon it. If, then, precautions are not taken, a flat foot may easily develop when it is again subjected to the weight of the body. The pains which ensue are frequently diagnosed as being simply rheumatic and treated as such without success. It is only when the foot is dealt with systematically for the flattened condition that relief is given to the severe pains. Sometimes at an early stage of the trouble it is sufficient to apply a flannel bandage to the slightly supinated foot, fixing the ankle with figure-of-eight turns. If this does not succeed, one must order a well-fitting lacing boot, furnished with an instep-support adjusted to the position taken up by the foot, and in addition employ massage and exercises for the supinator muscles.

In severe cases of rheumatism the articulations of the **spinal column** are exposed to attack, and a plaster bed to fix the trunk is then useful in relieving the pain. Difficulties in diagnosis may arise if the upper cervical vertebræ are affected, which is certainly a rare event (Jaksch, Coudray, Böger). A simultaneous or previous inflammation of other joints and a negative skiagraphic examination will support a diagnosis of rheumatism, which from the clinical aspect may quite simulate tuberculous spondylitis. The observations of Jaksch and Böger are of vital importance in this connection. They have found relaxation of the atlanto-axial articulation to occur, with consequent subluxation of the odontoid process. Backward displacement of the odontoid is liable to cause manifestations of compression of the spinal cord. In Böger's case the head was inclined forward and also to the side, a condition of right-sided wry neck.

Wry neck, with this articular origin, assumes some definite position dependent on the vertebral joints affected, and is thus distinguishable from the much more common torticollis due to muscular rheumatism. In the latter, movement is only restricted when it causes stretching of the painful muscles. Further, this type of rheumatic wry neck presents a marked tendency to recovery that is soon revealed by massage. For the arthrogenous form of torticollis one may try cautiously to correct it, and should employ a supporting collar. So long as the patient keeps his bed, one can also use extension acting on the head.

Chronic Multiple Arthritis.

Orthopædic treatment in *chronic polyarthritis* is usually only invoked when the patient has become incapacitated from walking owing to contractures, or when his pain persists in spite of, sometimes, indeed, as the result of, the most varied remedies. It falls then to the lot of the orthopædist to try to improve on the final result of methods of treatment, which unfortunately so far have failed to reach the causal condition, and which but seek to relieve the burdensome affliction with a whole host of medicaments, often with little or no success. It is a regrettable fact that the struggle against the development of contractures is often a vain one. This applies equally to the *primary chronic progressive polyarthritis* and to the *secondary chronic articular rheumatism,* the two conditions constituting the principal varieties of chronic arthritis which have been recently the subject of exact investigation by Hoffa and Wollenberg.

Primary chronic polyarthritis usually begins in-

sidiously, and pursues a chronic course, without fever, as a rule. Rheumatic pains set in and thickening of the joints occurs, commonly appearing first in the small articulations in the extremities and symmetrically, then gradually extending upward to involve the more central larger joints. Although fairly long remissions take place the disease is really a *progressive* one. The joint thickening is due principally to swelling of the capsule, and effusion is usually slight and does not last long. The synovial membrane, thickened, as it is at first, tends to develop a shaggy condition, particularly at the folds of the capsule, but later on it undergoes a process of shrinking which leads presently to a contracture of the joint thus affected.

In **secondary chronic articular rheumatism** contractures arise in the same way. It either happens that after rheumatic fever, when the fever and joint swellings have mostly disappeared, there ensues a stiffening of one or of several joints owing to fibrous or osseous ankylosis, or else the same changes appear in a number of central and distal joints after the fever has persisted, with but slight remissions, for weeks on end, uninfluenced by large doses of the salicylates (Přibram). The contractures developed in the two forms of chronic arthritis may reach the severest degree. As regards the fingers one often finds them pointing to the ulnar side at the metacarpo-phalangeal joints, over-extended at the proximal inter-phalangeal joints, and flexed and bent laterally at the distal joints. The hand is flexed and often subluxated; the elbow in most cases flexed and pronated, and the shoulder adducted The feet take up a varus or valgus position. The hips are flexed in either adduction or abduction.

It is a matter of importance that marked formation of new bone is not a feature of chronic multiple arthritis, and that certain changes seen by skiagraphy in the articular ends, such as thickening of the same or disappearance of the joint cleft, are capable of a purely mechanical explanation as the results of strain and pressure on the ends of bones, the resisting power of which is weakened. "When in the course of primary chronic progressive polyarthritis there ensues an alteration in the form of the articular ends, which is not explicable on purely mechanical grounds, but owes its origin much more to an active participation of the cartilage and bone in the change of contour, we have then before us a condition of *arthritis deformans* as a secondary complication of the progressive polyarthritis" (Hoffa and Wollenberg). This state of affairs may develop when the functional use of the joint acts as a stimulus. If the functional action is lost, as happens when a contracture has long existed, then that factor is wanting which gives rise to the deformative inflammation (Reiner).

As chronic polyarthritis, though not in itself a disease dangerous to life, renders the patient quite helpless on account of the stiffness and deformity, especially if the legs are implicated, the indications for the line of *treatment* to be followed are apparent.

When the tenderness in a joint is severe, fixation by a stiff, preferably plaster, bandage provides a sovereign remedy for easing the pain. Experience has convinced us that one need not have any fear whatever of favouring the permanent ankylosis of a joint by fixing it up. On the contrary, the prevention of irritative changes caused by movement cannot but help in preserving some

degree of mobility. At the same time the fixation bandage guards against the occurrence or the increase of a contracture. In the case even of a less tender joint, as the distorting forces are always at work, one must order the wearing for a prolonged period of a sheath splint appliance, and this should be fitted with an arrangement to produce extension of the affected joint. The mechanical treatment inaugurated after the acute stage must also be directed to obtaining increased extension. Only too frequently does one make the observation, that an alleged successful result of treatment by movement consists merely in an increased range of *flexion* of the contracted joint. Such a result is of course useless to the patient and is only calculated further to lessen his ability to walk, as that can be improved only by increasing the range of *extension* at the joint.

Accordingly, if it has not been found possible to prevent flexion-contractures developing in the **lower limbs,** we are of opinion that it is of the utmost importance to correct them as soon as the tenderness of the joint concerned has diminished. We endeavour to set matters right again, either by the use of ambulatory apparatus fitted with arrangements to produce extension, or else by the application of a series of plaster bandages. If these methods are not successful, operative measures must be adopted. Under anæsthesia the contracted tendons are first divided and then the flexed joints are straightened by modelling redressment. If the rigidity is very marked, or if ankylosis is present, we avail ourselves of osteotomy close to the joint for the correction of the deformity. This procedure is most conservative, and therefore preferable to a resec-

tion of the joint itself. In the very worst cases of contracture, osteotomy is also the method of choice on account of the risk of the occurrence of *fat embolism* attendant on too prolonged efforts at redressment. The pressing together of the atrophic articular ends of the bones is liable to drive fat from the marrow into the circulation. A slight consequent lipæmia is borne well enough, but if of considerable degree the pulmonary or cerebral capillaries become extensively blocked, and there then ensue the conditions of fat embolism described in an earlier part of this book [19].

The improvement secured by operation is maintained by the use of a plaster bandage worn for two or three months, and is then followed up by mechanical after-treatment. As regards the practising of movements, what has been stated before applies again here, namely, that increased *extension* is what is always to be aimed at perseveringly and it must be carefully maintained once it is secured.

In respect of the **upper extremities,** special mention must be made of the chronically inflamed joints of the shoulder and elbow. The tendency of the shoulder is toward an adduction-contracture. In this position the arm can be brought horizontal only with the help of movement of the shoulder-blade and no higher. It is therefore the movement of abduction which has to be practised diligently, and perhaps it may be desirable to produce fixation of the joint with the arm well abducted. It should likewise be pointed out that a stiff elbow is found to give least trouble if the ankylosis fixes it so that the forearm is set at a right-angle to the upper arm and is slightly supinated.

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[19] See p. 19.

Arthritis Deformans of the Hip.

Arthritis deformans of the *hip* is the most important practically of the monarticular inflammations coming under this description. Formerly it was viewed as an attribute of advanced years, and accordingly designated *malum coxæ senile*. Experience has shown, however, that even in youth deformative inflammation at the hip-joint is not by any means unknown (Lorenz).

As in arthritis deformans generally, the disease commences here also with changes in the cartilage and bone; the synovial membrane is then attacked secondarily when it becomes exposed to injury from the roughened joint structures. Wollenberg has put forward an apparently well-founded "vascular" theory of the etiology of the pathological process, according to which "a local disparity between the arterial supply and the venous return of the blood persisting for some time, brings about the regressive and progressive manifestations, which characterize the pathological picture of arthritis deformans."

The first sign of this affection of the hip is local pain which frequently radiates to the knee. When this occurs it sometimes gives rise to an erroneous impression as to the seat of the trouble.

The pain is felt most intensely when the patient takes the first steps after being at rest. After a while it improves, but active or continued movement increases the pain, and it often sets in after prolonged exertion when the patient is at rest, as at night. As the joint becomes increasingly sensitive a *limp* is noticeable, and the affected leg grows thinner owing to the muscular atrophy which is a feature of the joint disease. The extensors and abductors of the hip, the gluteal muscles, are particularly affected in this way.

In consequence of deficient power in the abductors, the adductor muscles gain the upper hand, become shortened and thus cause an adduction-contracture of the hip. The consequent limitation of abduction is a prominent feature of arthritis deformans coxæ, but it is one common to all conditions of the hip in which the function is imperfect, unless it happens that the position of the limb is determined by muscular spasm or ankylosis, or that a complete paralysis is present.

Accordingly, the appearance presented by *coxa vara* may be very similar to that seen in arthritis deformans of the hip. The adduction-contracture of the joint becomes still further increased, if the position of the trochanter becomes raised in consequence of the familiar changes taking place in the head of the femur and the acetabulum. In such event the head of the bone shows a great tendency toward subluxation, and one can see in the skiagram that the deformed, flattened or cylindrical head of the femur with the portion of its surface adjacent to the digital fossa has passed out of contact with the acetabulum, and therefore no longer lies below the level of the roof of the acetabulum. A slight degree of flexion of the joint may be detected in correspondence with the loss of power in the gluteus maximus, and the backward direction of the subluxation. As the disease progresses, grating is frequently to be felt on active or passive movement of the joint, and the range of movements is restricted.

As far as *treatment* is concerned we can only deal with a case symptomatically for lack of specific remedies. Internal medication with iodides, arsenic, &c., and hydrotherapy will be left out of account here, and only the mechanical measures referred to which are capable of influencing favourably the course of the disease, and

of securing for the patient great relief from his trouble and an improvement in his power of walking.

Generally a sheath splint apparatus is employed that takes the weight off the limb, in order, for one thing, to favour the state of nutrition of the articular ends of the bones, and in addition to relieve them of all functional activity for at least some time. An appliance of this kind can often render valuable service, and there is no objection to be raised to its *temporary* use. If, however, it is worn for years together, its value is diminished by the considerable harm which its use entails, for, as this ambulatory apparatus supports the tuberosity of the ischium, the whole of the limb below is deprived of its customary share of work. Whatever precautions may be taken in the way of massage, exercises, and baths, it is not possible to check the progress of the atrophy of disuse in the musculature and the bones. The end of it all is that the patient after a year or two is quite unable to go about without his apparatus. It is therefore desirable to make superfluous the use of an apparatus, and, if it is deemed necessary for the purpose of taking the weight off, or extending the hip, to employ it only for a limited period.

For the relief of the pain it is essential that any friction of the articular surfaces on each other should be prevented, and likewise any folding or twisting of the sensitive synovial membrane. One can ensure this most easily by putting an embargo, as it were, on the joint by mechanical means. The irritation caused by friction on the cartilage, and by wrinkling of the capsule is by no means the only source of impediment in walking. The patients limp and become tired, more particularly because even in early cases there is present as

a rule a joint contracture, which, though but slight, is still quite distinctly perceptible. This contracture consists, as has been previously explained, in slight flexion, adduction and external rotation, and it is easy to see that this faulty position, which is found almost constantly in all functionally weak hip-joints, must prove extremely unfavourable to the act of walking, which, in its turn, will lead to gradual increase of the contracture.

The position of flexion and adduction is just the one in particular in which the intrinsic strength of the hip-joint is *least* able to resist the effects of disordered function. The weakness of the gluteal muscles allows of the adduction of the hip and thereby the limping, while this is not compensated for by the strength of the capsule of the hip-joint above and behind, as this is the weakest part. As a result, the tendency to displacement being most favoured by the position stated, subluxation readily takes place, and the hip-joint becomes wholly incapable of bearing the weight of the body for any length of time without pain due to the strain on the joint.

A second indication as to a line of treatment is to be derived from the foregoing considerations, and that is to readjust the position of the defective hip-joint, so that it is better placed for supporting the weight of the body. Since this position of greatest static strength is that of full extension, or, rather better, slight over-extension, the aim then in correction of the joint is to secure the fullest hyperextension possible and a marked abduction. In this attitude the disordered hip-joint offers the *greatest intrinsic strength* of resistance to strains put upon it. This over-correction, which constitutes an

actual reversal of the position of the joint in contracture, we designate "*inversion*" (Lorenz).

The inversion is produced by the method of modelling redressment, and this is preceded by tenotomy or myorrhexis of the adductors, and in some circumstances by the division of the soft parts below the spine of the ilium (sartorius, tensor fasciæ femoris, fascia lata). When the joint has become sufficiently freed to permit of over-correction, the thigh is fixed, hyperextended and markedly abducted, by a plaster bandage which stops short of the knee. As soon as this is thoroughly hardened the patient may again get up and go about. The sole of the boot on the sound side is raised sufficiently to compensate for the artificial lengthening of the affected limb due to the abduction. This bandage is left on for several months, and is then replaced by a removable leather sheath which extends to the knee but leaves that joint free. This splint should secure the hip in a position of over-extension and modified abduction, since the more marked abduction makes the gait appear awkward.

In order to guard against a relapse of the contracture it is necessary to carry out after-treatment, which consists chiefly of vigorous massage of the gluteal muscles, and also of active and passive movements of the hip in the direction of abduction and hyperextension. If, after long continuance of this treatment, the limb has assumed habitually a position which satisfies the requirements of slight abduction and some degree of over-extension, then the sheath support may be left off. The exercises as described and the massage must, however, be persevered with further.

The foregoing comparatively energetic treatment can

hardly be pursued in the case of elderly patients. One will therefore seek to correct the position of the joint by gymnastic methods, and for the relief of pain in such cases one will certainly have to make use of a supporting appliance to take the weight off the limb for at any rate some time. In the majority, however, it will suffice for easing the patient's discomfort to apply to the hip a simple sheath splint or bandage that fixes the joint in its pathological position. When severe contractures fail to yield to gymnastic movements, subtrochanteric osteotomy is indicated, even in elderly individuals, as an operation which is simple and free from risk. The joint is left untouched, and once the position of the leg has been put right the condition of ankylosis is a direct advantage. On the contrary, *resection* of the hip-joint is a really severe operation and not to be recommended. Though it probably relieves the flexion-adduction contracture, it renders the joint operated on incapable of bearing weight during a long period, if not for all time.

Gonorrhœal Arthritis.

In the group of chronic infective joint diseases, *gonorrhœal arthritis* is one of the most to be feared. König and Bennecke have classified the various degrees of this type of infection according to their severity, thus: (1) Gonorrhœal hydrops, serous effusion; (2) sero-fibrinous inflammation; (3) suppurative arthritis; and (4) phlegmonous inflammation, which is the most virulent. Pain is particularly severe and often sets in suddenly. The inflammation has the tendency to overstep the limits of the joint capsule, in which case, though the effusion in the joint may be slight, there

is considerable swelling of the soft tissues around it and the skin becomes reddened and œdematous.

Gonorrhœal arthritis attacks most readily the knee-joint, then the hand, elbow, shoulder, hip, and foot. While several joints may be involved at the first, it is usual for the inflammation later on to settle down and persist in *one* of the large joints. Injury and pregnancy are of great importance as determining causes; many cases of so-called puerperal hip-joint disease are nothing else than gonorrhœal arthritis. The joints which undergo contracture assume the like positions as in other varieties of joint inflammation. Thus the hip is usually flexed, abducted, and rotated outward; more rarely adducted and rotated inward. The gonorrhœal inflammations are especially liable, as is well known, to lead to *stiffness* of the joints, and even to bony *ankylosis*, should the disease have progressed so far as to disorganize the articular surfaces and destroy the cartilage.

None the less, fixation of the inflamed joint is found to be necessary in the acute stage of the disease in order to lessen the severe pain. For this purpose a plaster bandage is best, as it secures most surely the complete rest of the sensitive parts. Experience has proved that the use of a plaster bandage does not contribute to the production of stiffness, provided it is only used during the period of acute inflammation. At a later stage one proceeds cautiously to encourage mobility in the joint by mechanical treatment. If, for instance, one is dealing with the knee, after removal of the plaster bandage a sheath splint appliance is worn, and its hinged joint is so arranged as to permit of the movement at the knee being gradually increased

more and more from the position of extension. The usefulness of the joint is also furthered by hot-air baths, hyperæmia, massage, and by passive and active movements.

As preventive measures, to oppose a tendency to contracture, one would apply shot-bags over the joint every day. For the same object one can have elastic bands fitted to a sheath splint apparatus, or the like, so as to cause extension. Already existing contractures are treated in similar fashion, but if these conservative measures fail in their object, or if they afford no prospect of success owing to ankylosis having taken place with the joint bent at an angle, then an operation is necessary to correct the faulty position. If the contracted joint still shows some mobility we employ the conservative plan of modelling redressment, but if ankylosis is present, an osteotomy close to the joint is then the most rapid and safe method of securing the desired result. As regards after-treatment, following osteotomy for ankylosis, the maintenance of the extended position is all that calls for attention; in the case of correction of a movable joint, a cautiously increased range of movement from the position of extension is to be effected.

Infective Arthritis.

In addition to gonorrhœal arthritis there is, as is well recognized, a number of other specific inflammations of the joints which may present a great similarity to rheumatic polyarthritis, and in former times indeed were not strictly distinguished from it, so far as the non-suppurative inflammations were concerned.

Specific joint inflammations may arise in the course

of *typhoid, pneumonia, erysipelas, diphtheria, influenza,* also in association with *measles, scarlet fever, small-pox, cerebrospinal fever, psoriasis,* and in *pyæmic* affections.

Following Franke, four varieties of secondary joint affections may be distinguished, thus :—

(1) Simple arthralgia.

(2) Swelling and serous or sero-fibrinous effusion.

(3) Suppuration and phlegmonous inflammation around the joint.

(4) Severe osteo-arthritic changes associated on the one hand with suppuration involving the bones, on the other hand with formation of granulation tissue, which either leads to simple contraction of the joint capsule, or involves the cartilage, which becomes vascularized and undergoes complete transformation into fibrous tissue, leading to fibrous adhesions between the bones or even osseous ankylosis.

These joint affections may pursue an acute course or pass into a chronic condition, or they may present initially a chronic type. They set in either at the beginning of the causal disease, or later on in the stage of recovery, but sometimes the joint disease may appear primarily, as has been observed for instance in pneumococcal arthritis (Zesas).

The infective joint inflammations occurring in *sucklings* deserve special attention. They mostly occur within the first few weeks after birth, and attack the hip and knee joints in particular. If one can exclude syphilis and tubercle, the likely infective organisms are gonococci, staphylococci, pneumococci, or streptococci (Raillet), and auto-infection from the intestine by *Bacterium coli* has also been held responsible (Drehmann).

The inflammation in the *hip* is purulent, and attacks either the synovial membrane primarily, or else extends from the epiphysis to involve the joint secondarily. After escape of the pus, often all that may remain is a minute white scar over the hip which, years later, may be still an indication of the previous inflammation, the condition of the joint having been restored to the normal. But sometimes there ensues a *dislocation* owing to the *distension* of the joint, and not infrequently a dislocation in consequence of severe *destruction* of the structures of the joint (Wette, Drehmann).

The *treatment* of these dislocations is similar to that of congenital dislocation of the hip, for which they are often mistaken. If the radical operation of reduction is not possible on account of too great alterations in the joint, we then avail ourselves of the method, previously mentioned, of "inversion" of the joint, so that the position of the head of the femur, which is displaced backward, may be improved upon, and thus render the limb more capable of supporting the weight of the body.

The deformities remaining after secondary infections of the joints are treated on the same principles as were discussed in connection with chronic articular rheumatism. Contractures which are not too severe are dealt with by tenotomy or myotomy of the contracted muscles, followed by remodelling correction. Severe or very unyielding contractures are treated most conservatively by osteotomy close to the joint. This also applies to deformities which are ankylotic, that is to say, when caused by the articular ends of the bones having become osseously united.

The pathological *dislocations* of the *hip* which may take place as the result of severe *osteitis with arthritis*

call for an individual treatment. If, as is then usually the case, the alterations in the joint structures are extensive, a reposition of the dislocated femur is no longer possible, and one must aim at placing it so that the limb will be in the best position possible for bearing the weight of the body. This state of affairs will be secured by means of the operation of "inversion." It has already been set forth that the over-extended, abducted position renders a disordered joint more steady and capable of giving support. The explanation of this greater strength is no doubt to be found in the fact, that in over-extension the more resistant ligaments in the front of the joint capsule (ilio-femoral or Y-ligament of Bigelow) are brought into action, while at the same time in abduction the iliac bone is kept depressed on the side of the affected limb, and in relation to the laterally opposed upper end of the femur takes over the function normally performed by the roof of the acetabulum, though, of course, it is set more vertically. It is thus possible in the case of a disorganized hip-joint, of which the radical cure is impracticable, to make it more secure and better able to bear weight, by enforcing a habitual attitude of over-extension and abduction. With this object in view, one does not only aim at an over-correction of the posture of the limb, but also at the same time at a transposition forward of the dislocated upper end of the femur so that it comes to lie close under the anterior superior spine, the operation of pseudo-reposition. The other details of these plans of treatment have been described previously in connection with the treatment of arthritis deformans of the hip.

In *ankylosis* of the joints, on the other hand, conse-

quent on osteo-myelitis, when the position in which they are fixed renders them functionally useless, the corrective treatment consists exclusively in osteotomy close to the joint (*e.g.*, subtrochanteric or supracondylar osteotomy of the femur, or of the tibia below the head, &c.), as these simple operations, free from risk, are without question greatly preferable to even the most conservatively performed intra-articular resection. This applies equally to ankylosis remaining after previously existing *tuberculous* disease.

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(The items marked * contain lists of the literature dealing with the subject matter.)

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